4. Aquatic Organisms

4.1 Fish

Communities of fishes differ among main channels of rivers, off-channel features of rivers, ponds, and streams in the study area, with each water feature providing a unique combination of water temperature, food, cover, and water velocity. Furthermore, fish assemblages change with the seasons and are influenced by the presence of hatchery fish, fishing pressure, and fishing regulations and their enforcement. The seasonal connection of a water body with a main river will also dictate fish community structure and survival of individual species, especially over the summer.

Water bodies within the study area support 24 native and 11 introduced species or stocks of fish (Table 22). Three species are federally listed under the Endangered Species Act, including spring Chinook salmon (Threatened), Oregon chub (Endangered), and bull trout (Threatened). Among the five native species of salmonids (Chinook salmon, cutthroat trout, rainbow trout, mountain whitefish, and bull trout) using water bodies in the study area, all are common except for bull trout. These listed fish species, along with cutthroat and rainbow trout, are considered key species in the future management of rivers and streams in the study area . Their life histories are summarized below.

Table 22. The 24 native and 11 introduced species or stocks of fish found in streams, rivers, and ponds of the MECT study area.

Family	Native	Introduced
Salmonidae	Spring Chinook salmon	
Salmonidae	Cutthroat trout	
Salmonidae	Resident rainbow trout	Hatchery rainbow trout
Salmonidae		Hatchery steelhead trout
Salmonidae	Bull trout	
Salmonidae	Mountain whitefish	
Catostomidae	Largescale sucker	
Catostomidae	Mountain sucker	
Cyprinidae	Redside shiner	
Cyprinidae	Chiselmouth	
Cyprinidae	Peamouth	
Cyprinidae	Northern pikeminnow	
Cyprinidae	Longnose dace	
Cyprinidae	Speckled dace	
Cyprinidae	Leopard dace	
Cyprinidae	Oregon chub	
Pertromyzontidae	Western brook lamprey	
Pertromyzontidae	Pacific lamprey	
Cottidae	Paiute sculpin	
Cottidae	Shorthead sculpin	
Cottidae	Reticulate sculpin	
Cottidae	Torrent sculpin	
Percopsidae	Sand roller	
Gasterosteidae	Three-spine stickleback	
Acipenseridae	White sturgeon	
Ictaluridae		Brown bullhead
Ictaluridae		Yellow bullhead
Poeciliidae		Mosquitofish
Cyprinidae		Goldfish
Centrarchidae		Common carp
Centrarchidae		Bluegill
Centrarchidae		Largemouth bass
Centrarchidae		Smallmouth bass
Centrarchidae		White crappie

Spring Chinook

Spring Chinook salmon occupy the Willamette River within the study area during two life stages. Adults returning to the Willamette basin after 3 to 5 years in the ocean will pass through the area to upstream hatcheries and spawning areas in the McKenzie and Middle Fork Willamette Rivers from May to mid-July. They commonly use deep pools in the main channel and slackwater areas at night to hold. As temperatures rise in the early summer, they move out of the Willamette River into the cooler McKenzie River or Middle Fork Willamette River. Spring Chinook salmon do not spawn in reaches of rivers within the study area.

Eggs hatch and fry emerge from the redds beginning in late winter.   Chinook salmon fry move downstream from upper reaches of the McKenzie River and Middle Fork Willamette River

beginning in March. They feed in shallow water where the velocity is low. Many of these fry continue to move downstream later in the spring, but a number become resident for up to a year. A portion of these resident juvenile Chinook migrate downstream in the fall. Others will remain in the river until the next spring and then migrate. During the summer, juveniles commonly occupy pools immediately downstream of main channel riffles where they are assured an abundant supply of food. They readily compete with cutthroat and rainbow trout in these pools and become large (up to 8 inches long) by the end of summer (unpublished data, Oregon Department of Fish and Wildlife, Corvallis). It is believed that these year-old migrants are well-suited for survival in the ocean because of their large size when they enter the ocean and because they have practice competing with other fish and avoiding predation (Kirk Schroeder, personal communication, ODFW Research, Corvallis). Newly-released hatchery fish have no practice with avoiding predation and can be found schooling at the surface of the water accompanied by an entourage of cormorants as they migrate downstream.

Summer temperatures in the McKenzie, Middle Fork Willamette, and Willamette River are favorable for juvenile Chinook salmon . Because of the diversion of cool water from the McKenzie River, Cedar Creek also has water that is cool enough to support them in the summer. The occupation of other study area waters by juvenile Chinook salmon during the summer is unknown but may include the Springfield Mill Race and the Alton Baker canoe canal. The inlets that divert water from rivers into the Springfield Mill Race, the Canoe Canal, and Cedar Creek are not screened to prevent juvenile fish from entering at the upstream end. Only Cedar Creek has a way for juvenile fish to voluntarily enter from the downstream end.

During the winter, juvenile Chinook salmon probably use an expanded set of waters in the study area, although little has been done to document their presence. Sampling has revealed that juvenile spring Chinook move into the Mohawk River, into small tributaries of the Willamette River near Albany, and Oak Creek near Corvallis (Gary Galovich, ODFW, Corvallis, personal communication) and into seasonally flooded ponds (Bailey and Baker 2000) during the winter. Presumably, they move into these areas to escape high-velocity water and access terrestrially-based food sources (Bailey and Baker 2000). Waters in the study area that are likely to have juvenile Chinook salmon use only during the winter include the lower portions of East Santa Clara Waterway, Spring Creek, Dodson Slough, Debrick Slough, Russell Creek, Oxley Slough, Pudding Creek, and two small streams on the south bank of the McKenzie River where reaches 10 and 11 connect. In addition, ponds and other off-channel features connected to the main river during high flows also probably have juvenile Chinook salmon. Historically, streams that flow into the Long Tom River did not support spawning or incubation of spring Chinook salmon due to insufficient flows during the spawning period for spring Chinook (Jeff Ziller, ODFW, personal communication). The lower Long Tom system does provide refugia and rearing habitat for juvenile spring Chinook, however, Fern Ridge Dam and a number of irrigation dams block access from those areas into the MECT study area (Jeff Ziller, ODFW, personal communication).

Juvenile spring Chinook salmon found in the waters of the study area can be from one of several types. They can be offspring from either hatchery or wild adults that spawn naturally in the rivers, hatchery juveniles that are not marked as such, either because of a mistake or because they were intentionally released without a clipped adipose fin (usually as fry from a hatchery), or

a hatchery fish with a clipped adipose fin. A missing adipose fin will positively identify a fish as being from a hatchery, but an intact adipose fin does not mean they are offspring of wild fish.

There is currently no known successful spawning of "wild" Chinook salmon in the upper Willamette River basin other than in the McKenzie River upstream of Leaburg Dam. Spring Chinook of hatchery origin spawn in Fall Creek, a tributary of the Middle Fork Willamette River, below the dam, but the success of this spawning is questionable because flows in Fall Creek are dramatically raised and lowered, sometimes daily, by the Corps of Engineers to manipulate power production at Dexter Dam (Jeff Ziller, ODFW, Springfield, personal communication). The raising of stream levels can cause spawning redds to become scoured because of high-velocity water or become desiccated when low flows expose them to the air.

Surplus adult spring Chinook salmon from the hatcheries are placed upstream of all six of the major dams in the McKenzie and Middle Fork Willamette Rivers in order for them to spawn in waters upstream of the reservoirs. Although none of the dams have fish passage facilities, some of their offspring are known to successfully move downstream through the turbines or spillways and downstream to the ocean (Jeff Ziller, ODFW, Springfield, personal communication). They return from the ocean and are counted as non-hatchery fish since they do not have a clipped adipose fin.

The spring Chinook entering the McKenzie River are mostly hatchery fish, although about 2,000 are referred to as "wild" (Jeff Ziller, ODFW, personal communication). Spring Chinook are counted at the ladder that goes over Leaburg Dam. Early-spawning salmon with an intact adipose fin are counted as wild and adults without an adipose fin or late-season spawners with an adipose fin are considered to be hatchery fish. A majority of hatchery fish stop at the hatchery short of Leaburg Dam, but it is unknown how many of the hatchery fish going over the dam are misidentified as wild fish.

The number of spring Chinook salmon entering the McKenzie River has been increasing since 1997 (Figure 37). Most likely, this increase is due to improved ocean conditions and restrictions on ocean and river fishing. The Chinook salmon returning to the river in 1993 also benefited from favorable ocean conditions.

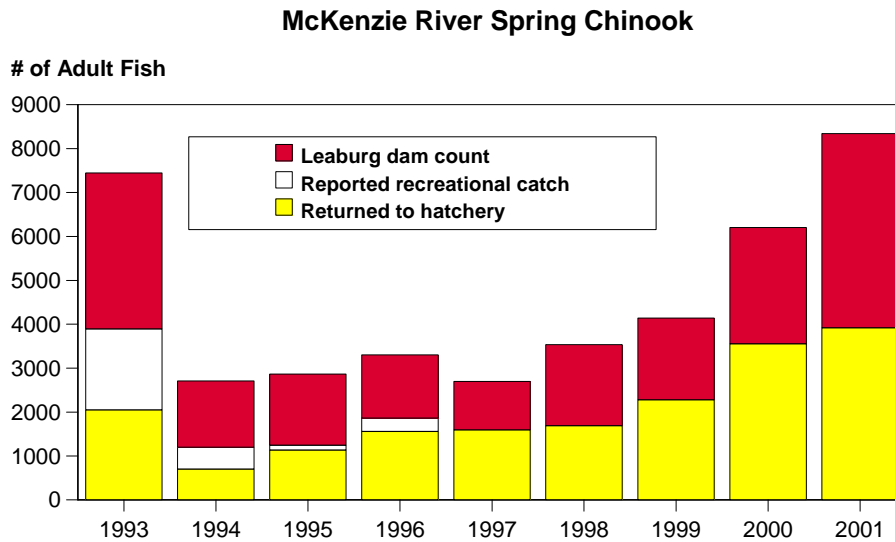**McKenzie River Spring Chinook**

# of Adult Fish

Figure 37. Number of spring Chinook salmon counted at Leaburg Dam, caught at the hatchery, or reported caught from 1993 to 2001 (ODFW web site, Springfield office).

Oregon chub

The Oregon chub is a small minnow found only in the Willamette River basin. At one time the Oregon chub occupied most lowland areas where there was shallow, slow-moving water, such as sloughs, beaver ponds, oxbows and side channels. About 25 isolated populations are known to exist now with most in artificial ponds.

Historically, floods that created Oregon chub habitat were common. When rivers flooded, they scoured new side channels and backwaters while isolating channel segments in other areas to create ponds. Oregon chub were well-suited to these areas and particularly thrived where aquatic vegetation was plentiful. However, upstream reservoirs altered these channel-altering processes by reducing peak flows and preventing river meandering.   Habitat loss also resulted from bank riprap, channelization of streams and draining and filling of wetlands. More importantly, exotic species such as bass, bluegill and mosquito fish were introduced to the Willamette basin. These species compete for habitat preferred by Oregon chub or prey on them directly (Scheerer 2000). Sharp declines in a number of established populations occurred after the high water of 1996. The flood transported introduced species into ponds that had previously been isolated from streams and rivers and these fish preyed upon and competed with Oregon chub. Today, most of the stable populations of Oregon chub exist in artificial ponds where introduced fish are purposely excluded (Paul Scheerer, Oregon Department of Fish and Wildlife, Corvallis, personal communication).

In 2001, a small population of Oregon chub was found in backwater features of the McKenzie River (south side of river in reach 12). The area harbored no introduced fish species, probably because the waters are fed by subsurface flow of the river which is too cold for introduced fishes.

A subsequent survey in 2002 resulted in the discovery of Oregon chub in a side channel of the Coast Fork Willamette River near the Interstate 5 bridge (upstream of the study area). Future surveys may reveal the location of other isolated populations within the study area, especially where introduced fish do not thrive.

Bull trout

There have been only two accounts of bull trout in the study area during recent decades. A large adult bull trout (21 inches long) was caught by the Oregon Department of Fish and Wildlife with a seine net at the mouth of the McKenzie River in 2000 and a small adult (12 inches) was confiscated from a fisherman in the lower McKenzie River in 2002. Bull trout are probably rare in the lower McKenzie River since hardly any have been reported and they are easily caught on artificial flies.

Bull trout are more common in the upper McKenzie River where they can find the cold water that is essential for egg development and juvenile rearing. As adults, bull trout expand their territory into warmer water in search of food, which is mainly small fish.

Three populations of bull trout exist in the upper McKenzie River and all are isolated from each other by dams. Only the downstream population located in the main channel of the McKenzie River near the town of McKenzie Bridge can migrate down the McKenzie River. Efforts to increase the spawning success and food supply of bull trout and reduce poaching by anglers have been successful during the last decade. Fishing restrictions do not allow angling for bull trout. Efforts are underway to re-introduce bull trout into upper portions of the Middle Fork Willamette River basin.

Cutthroat and rainbow trout

Cutthroat and rainbow trout are found in study area rivers and cutthroat trout also use connected off-channel areas and seasonally use streams of all sizes in the Willamette River basin. Adult cutthroat trout are often found spawning in the headwaters during late winter or spring. They quickly move downstream after spawning. Juvenile cutthroat trout are rarely found in rivers of the Willamette basin. Instead they stay in their natal streams for the first 2 years and then some move downstream to waters that offer a better food supply (Moring et al. 1988). Some cutthroat become resident in streams their entire lives and have a stunted form (usually less than 8 inches); the others move into the rivers where they can reach a length of up to 16 inches. Certain tributaries of the Mohawk River basin have been identified as important areas for spawning by cutthroat trout that normally reside in rivers of the study area (Huntington 2000).

Native rainbow trout in the upper Willamette River basin (often called redbands) are genetically distinct from steelhead trout naturally found in lower portions of the Willamette. Unlike cutthroat trout, redband rainbow trout spend most of their lives in rivers and large streams.

4.1.1 Fish sampling in study area streams

Fish assemblages for streams within the MECT study area have never been quantified except for sampling of a short reach of Amazon Creek (near the fairgrounds) by the EPA Research Laboratory (Corvallis) in July of 1993 and 1996. Results from this study indicate that all species found in the stream were tolerant of warm water (Figure 38). Most fish were the native redside shiner and speckled dace. Surprisingly, only a few introduced warm water fish were present; usually bluegill and largemouth bass thrive in valley streams with warm water. Water temperature exceeded 80 deg F in this reach during the summer of 2001.
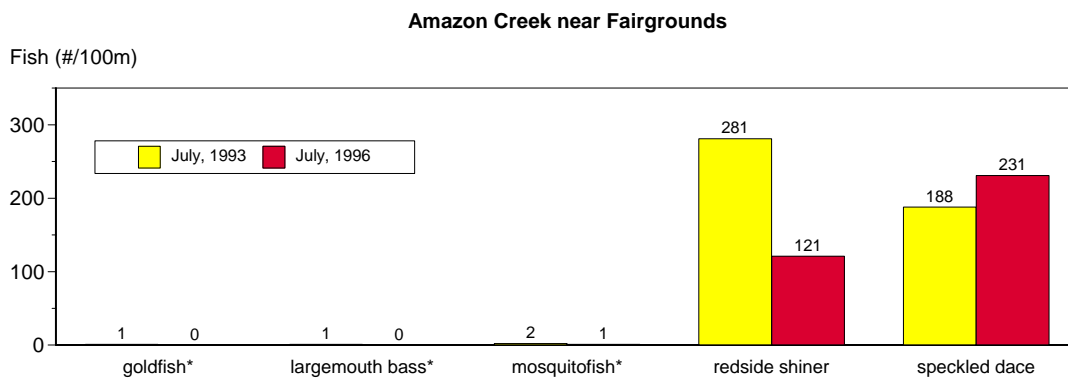
Amazon Creek near Fairgrounds

Fish (#/100m)

[Bar chart showing fish counts by species]

- goldfish*: July 1993 = 1, July 1996 = 0
- largemouth bass*: July 1993 = 1, July 1996 = 0
- mosquitofish*: July 1993 = 2, July 1996 = 1
- redside shiner: July 1993 = 281, July 1996 = 121
- speckled dace: July 1993 = 188, July 1996 = 231

Figure 38. Daytime backpack electrofishing results for a reach of Amazon Creek near the fairgrounds in July, 1993 and 1996. Data provided by EPA Research Laboratory in Corvallis. An asterisk designates that the species has been introduced to the Willamette River basin.

Most streams in the study area have been verified to be fish-bearing or suspected of being fish-bearing for much of their length (Map 11) through informal surveys and sightings conducted over the last few decades. Usually , confirmation of the upper extent of fish use in a stream involves electrofishing during the late winter or early spring, a time when cutthroat trout are at their highest position in the watershed. Cutthroat trout usually hold the most upstream position in small streams of the Willamette River basin, although the upstream extent of fish use will sometimes be defined by the presence of sculpin or redside shiner if cutthroat trout are excluded from the stream by man-made or natural barriers. Most year-round ponds and some of the larger stormwater waterways are also used by fish. Ponds isolated from the rivers usually have fish but are dominated by introduced species.

The source of information used for fish-bearing streams was the detailed USGS maps updated yearly by the Oregon Department of Forestry and Department
of Fish and Wildlife. Field surveys are used to define on this map whether or not stream segments are fish-bearing. There are many small streams that have never been surveyed so the information is incomplete. A water body was designated as having possible fish use if it appeared to have the characteristics of a fish-bearing stream or if the local Department of Fish

and Wildlife biologist's notes on the Department of Forestry maps indicated that it probably had fish.

The "Essential Indigenous Anadromous Salmonid Habitat" maps produced by the National Marine Fisheries Service are not intended to designate which streams do and do not have fish. These maps show a variety of stream channels, both those that have fish and those that can influence downstream fish-bearing waters.

4.1.2 Fish sampling in study area rivers

Until recently, there had been no systematic sampling of fish communities in the MECT study area. A study conducted for the McKenzie Watershed Council in September, 1999, and March, 2000 (Andrus et al. 2000), provided information on fish communities within various water types in the McKenzie / Willamette confluence area. This area included the Willamette River downstream of the Beltline Road Bridge to about 4 miles downstream of the McKenzie River confluence and the McKenzie River from its mouth to the Interstate 5 Highway Bridge. Boat electrofishing of the margins of water features with various bank types was conducted at night (a time when fish move close to shore and are less spooked by the sampling boat) in early spring and again in late summer. Main channel reaches, alcoves, gravel pit ponds, and natural ponds were sampled during this study.

Another study, conducted for the City of Eugene, provided information on fish communities along the main channel of the Willamette River from the Middle Fork Willamette / Coast Fork Willamette confluence to the McKenzie River confluence (Andrus et al. 2000) utilizing the same methods and personnel of the confluence study . Sampling occurred in March, 2000, and September, 2000.

Additional information on Willamette River main channel and alcove fish assemblages was obtained from a study sponsored by the EPA Research Laboratory in Corvallis for sites between Corvallis and the McKenzie River confluence for sampling periods in summer, 1988, and March, 1999 (Andrus, unpublished data). Catch results for each of the three studies were pooled and expressed in terms of number of fish caught per 100 feet of bank sampled in the discussions below.

Fish community structure

All reaches of all rivers in the MECT study area support an array of fish species. For small fish (2.4 to 7.9 inches long), the number of native fish genera was lowest in the Willamette River upstream of Springfield (reaches 20-22, 27) and in the lower McKenzie River (reaches 3-5) and was highest in the Willamette River downstream of Skinner Butte (reaches 15-16) (Figure 39). The number of genera is similar to the number of species, except that sculpin species were combined into a sculpin group and dace species were combined into a dace group.
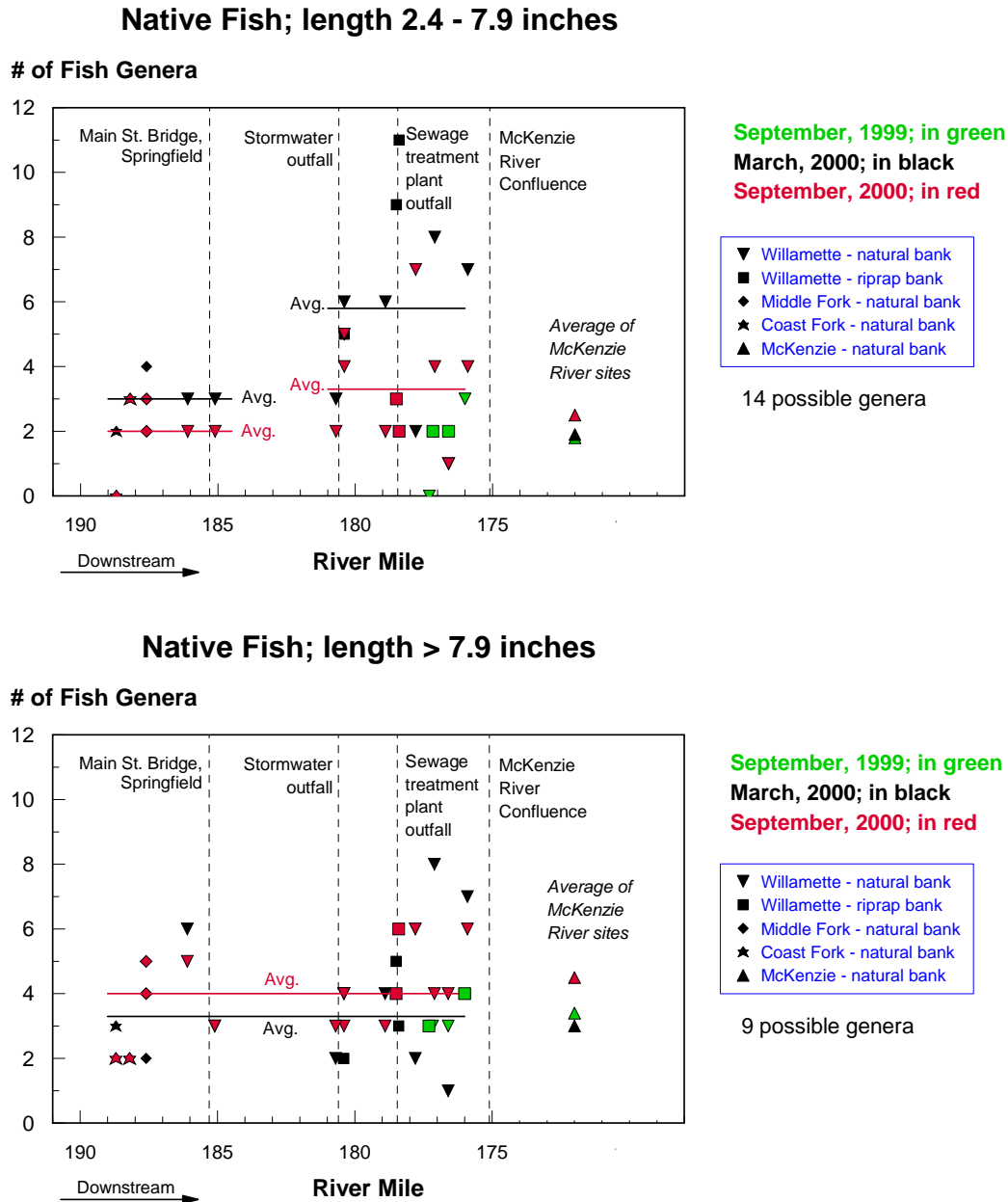
Native Fish; length 2.4 - 7.9 inches

# of Fish Genera

Native Fish; length > 7.9 inches

# of Fish Genera

Figure 39. The number of fish genera for three sampling periods and two fish length classes. For the lower McKenzie River, 5 sites were sampled in September, 1999, 4 sites in March, 2000, and 2 sites in September, 2000.

There was no pattern in genus abundance for large fish (greater than 7.9 inches). The high diversity of small fish in the most urbanized portion of the Willamette River during March may be caused by the extra nutrients provided by stormwater and point discharges. These nutrients can increase primary productivity and result in a more diverse food base, thereby attracting a greater diversity of fishes. The greatest genus diversity was found at two sites nearest the wastewater treatment outfall.

In this study, the catch per unit effort is expressed as the number of fish caught per 100 feet of bank sampled. The catch per unit effort does not indicate the absolute size of the population of fish being sampled, but is merely an index of abundance. Hereafter, we refer to catch per unit effort as "relative abundance." Species of fish were assigned to one of four different groups. The group, salmonids, consisted of salmon, trout, and mountain whitefish. The group, scrapers, consisted of suckers and chiselmouth which obtain their food by scraping periphyton off rocks and other bottom substrate. All other native fish were considered other native and non-native fish were classified as introduced.

For all sites combined, the relative abundance of small fish declined from March to September, with nearly all of this decline due to fewer salmonids (Figure 40). Specifically, small mountain whitefish left the area after March in large numbers (Figure 41), presumably to seek out cooler water in the Middle Fork Willamette River or the McKenzie River. In addition, few small Chinook salmon remained by the end of the summer and probably migrated downstream at various times throughout the summer.

Large salmonids did not decline over the summer, but rather increased (Figure 40), due mostly to an increase in cutthroat trout. Some of these trout may be summer refugees from the warm Coast Fork Willamette River and Mohawk River.

The relative abundance of large scrapers increased from March to September. Most of the scrapers were largescale suckers. In early spring, when food supplies in the main channel are scarce, largescale suckers will congregate in alcoves and other off-channel areas (Andrus et al. 2000). Presumably, these areas have an early-season growth of periphyton on rocks and other surfaces and the low velocity in these areas help the scrapers avoid expending energy battling strong currents in the main channel.

The relative abundance of other native fish declined from March to September for small fish, largely due to a decline in redside shiners, but increased for large fish, a result of more pikeminnow (Figure 42). Redside shiner are heavily predated upon by large fish, great blue heron, and other animals and so their decline over the summer is not surprising. Yet, the reasons for seasonal increase in the relative abundance of large pikeminnow is unknown.
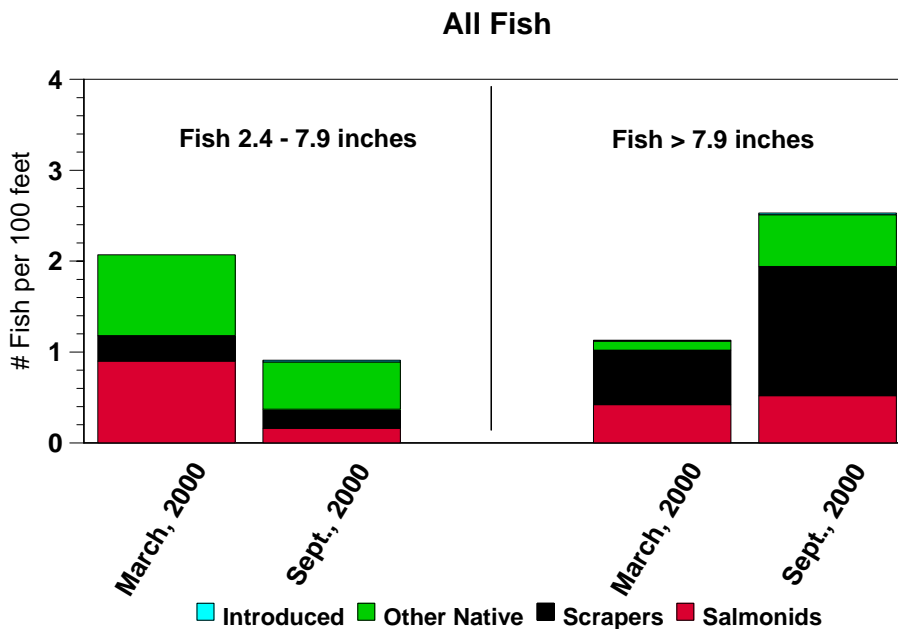
All Fish

Figure 40. Relative abundance of fish, by group, sampled along the edges of the Middle Fork Willamette River (2 sites), Coast Fork Willamette River (2 sites), and the Willamette River downstream to the McKenzie River confluence (12 sites) (Andrus 2000).

Salmonids

Figure 41. Relative abundance of salmonids, by species, sampled along the edges of the Middle Fork Willamette River (2 sites), Coast Fork Willamette River (2 sites), and the Willamette River downstream to the McKenzie River confluence (12 sites) (Andrus 2000).
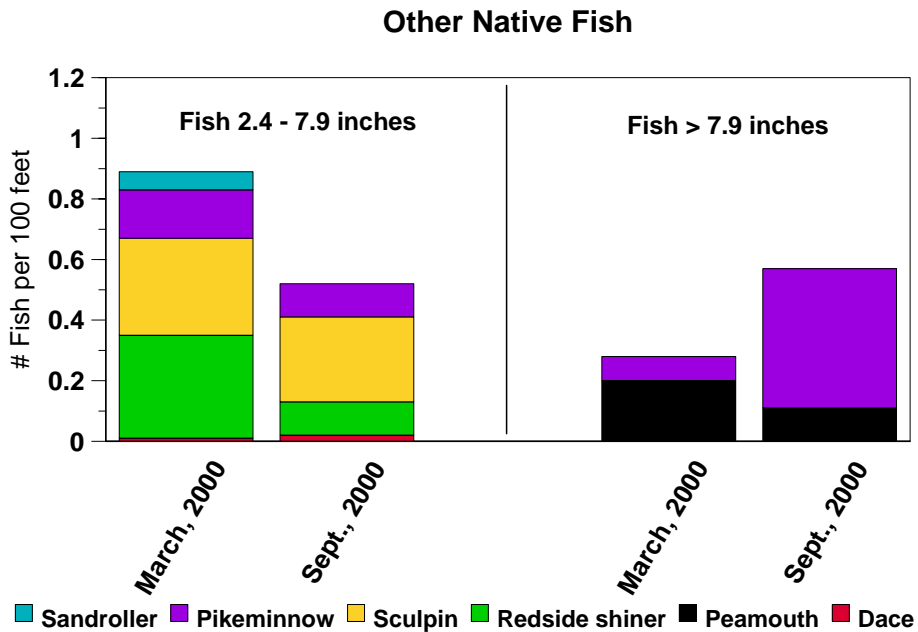
Other Native Fish

Figure 42. Relative abundance of other native fishes, by species, sampled along the edges of the Middle Fork Willamette River (2 sites), Coast Fork Willamette River (2 sites), and the Willamette River downstream to the McKenzie River confluence (12 sites) (Andrus 2000).

Introduced fish were rarely caught in the main channel of these rivers during either sampling periods. The species that were caught included largemouth bass, smallmouth bass, and common carp.

Longitudinal variations in the relative abundance of native fish in the Willamette River throughout the study area differed between seasons and between the two fish size classes. The relative abundance of small native fish in the Willamette River varied considerably among sites but, in general, was less upstream of Springfield than downstream (Figure 43). The relative abundance of small native fish in the McKenzie River was also low. Small fish were more abundant in March than in September at almost every site. In contrast, large native fish were more abundant in September than in March. This difference was most pronounced in the Willamette River downstream of the wastewater treatment plant. Large fish in this section may benefit from nutrients released from the wastewater treatment plant effluent and a river bottom dominated more by cobbles and less by bedrock and fine material.

Native Fish; length 2.4 - 7.9 inches

# of Fish per 100 ft of bank

Native Fish; length > 7.9 inches
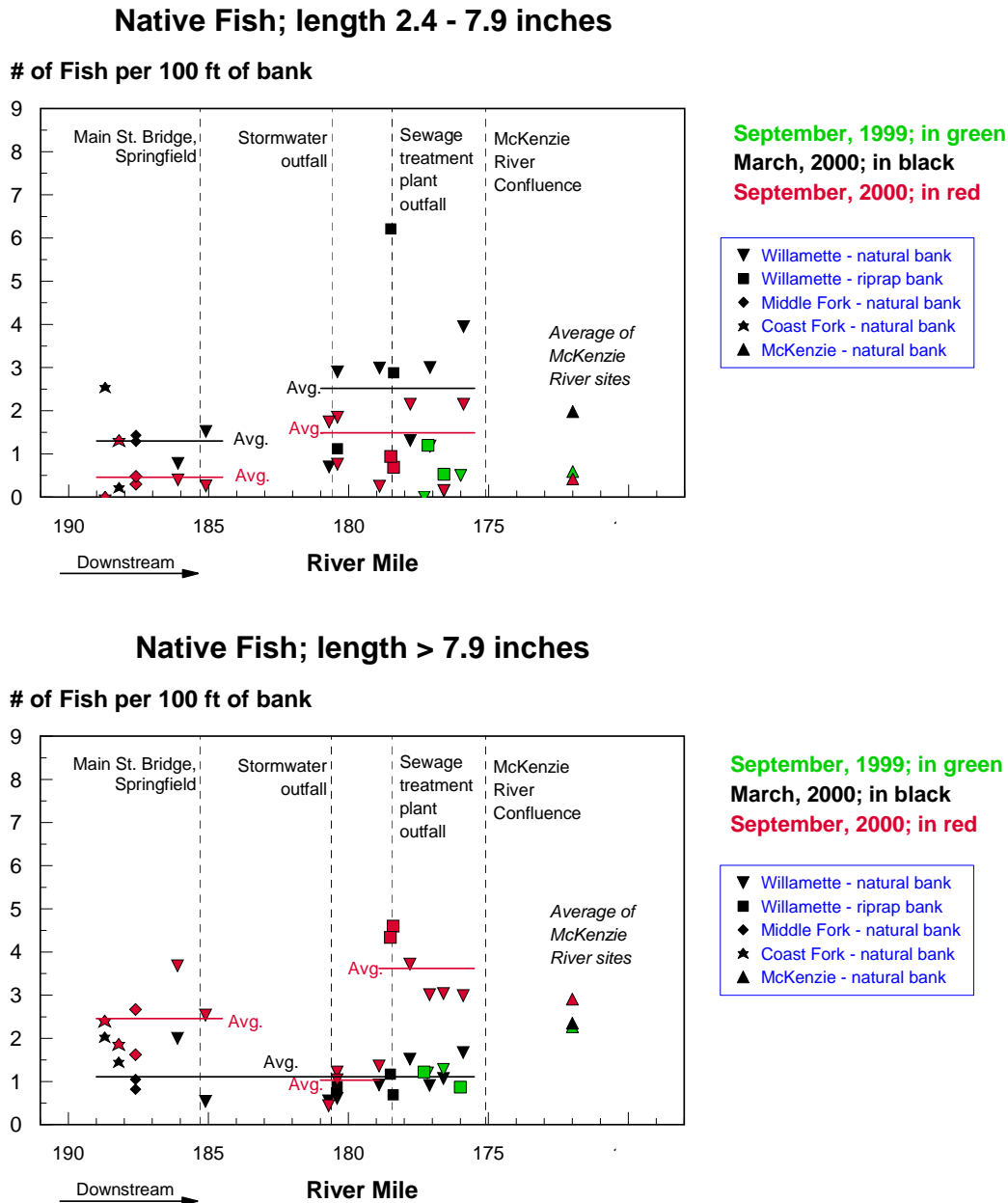
# of Fish per 100 ft of bank

Figure 43. Longitudinal differences in the relative abundance of all native fish for the main channel Willamette River and McKenzie River during March and September (Andrus 2000, Andrus et al. 2000). McKenzie River values are shown as an average of 4 sites in March and 5 sites in September.

Salmonids

The relative abundance of small salmonids increased in a downstream direction for the Willamette River in March, boosted by an increase in rainbow trout for sites closest to the McKenzie River confluence (Figure 44). Portions of the McKenzie River and its tributaries are known for their high native rainbow trout populations.

Surprisingly, all small salmonids caught during March within the main channel of the lower McKenzie River, where banks were natural material or riprap were mountain whitefish. Some small salmonids were caught within alcoves and along main channel sections with rock barbs. Rock barbs are made of large angular rocks placed at a right angle to the bank (sticking out 20 to 30 feet from the bank). This creates a large pool of slow water immediately downstream of the barb that allows fish to withstand downstream movement yet puts the fish close to fast water in order for them to initiate feeding forays. Small mountain whitefish were nearly absent during the September sampling and probably moved upstream to cooler water.

The section of the Willamette River between the Springfield Bridge and Beltline Road had the fewest large salmonids during March and September, mostly due to a scarcity of mountain whitefish (Figure 45). Mountain whitefish feed on small aquatic insects that favor loose gravel substrates in relatively shallow water. This section of the Willamette River once had extensive gravel deposits, but they were mined from the river in the 1940s and 1950s and the channel was deepened and narrowed when the west bank was developed. This has probably reduced the abundance of aquatic insects and, consequently, has created less favorable habitat for large mountain whitefish.

The relative abundance of large rainbow trout in March was not appreciably greater in the McKenzie River than in the Willamette River probably because they spawn mainly in March and many may have temporarily moved upstream in the McKenzie River to spawning grounds. In September, both large rainbow trout and cutthroat trout were more numerous in the lower McKenzie River than elsewhere. In fact, the values shown in Figure 45 for the McKenzie River are probably understated because the electrofishing boat brought far more trout to the surface of the water than the netter could gather.
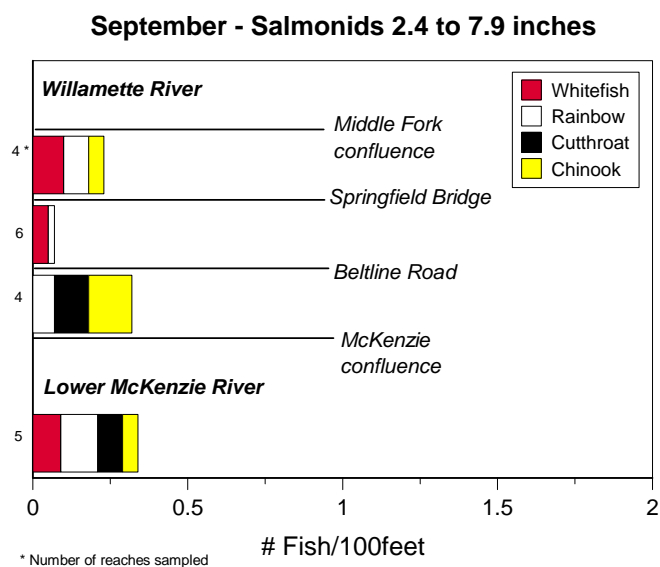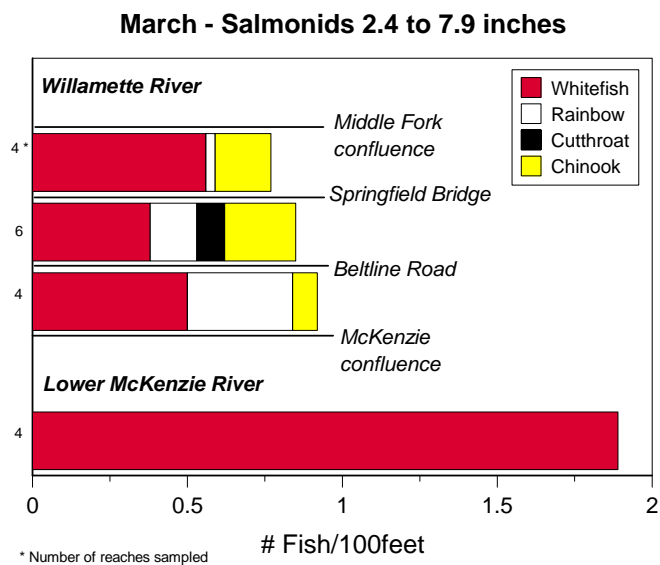
Figure 44. Longitudinal differences in the relative abundance of small salmonids for the main channel Willamette River and McKenzie River during March and September (Andrus 2000, Andrus et al. 2000).

March - Salmonids greater than 7.9 inches

Willamette River

Middle Fork confluence

Springfield Bridge

Beltline Road

McKenzie confluence

Lower McKenzie River

Whitefish
Rainbow
Cutthroat

Fish/100feet

* Number of reaches sampled

September - Salmonids greater than 7.9 inches

Willamette River

Middle Fork confluence

Springfield Bridge

Beltline Road

McKenzie confluence

Lower McKenzie River

Whitefish
Rainbow
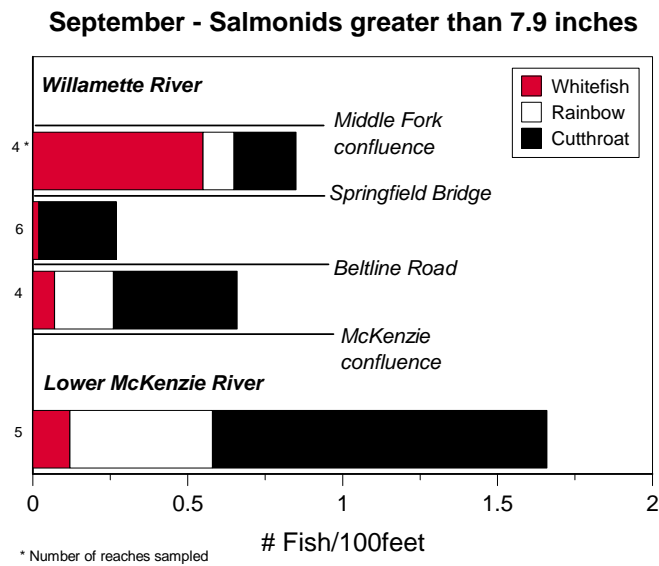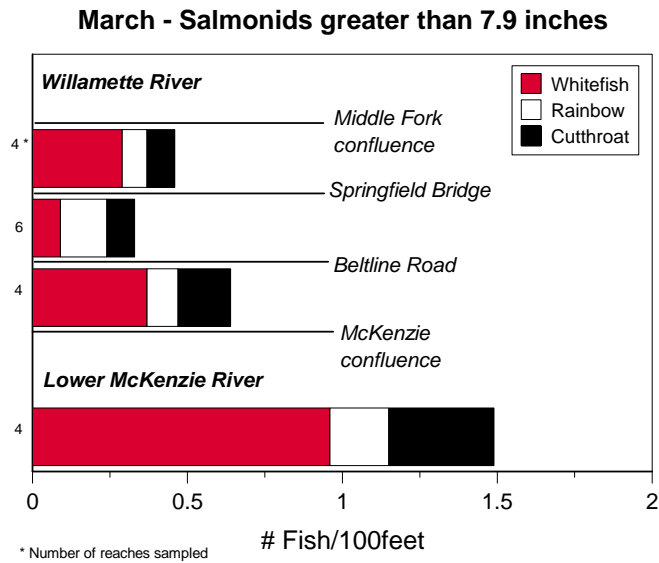Cutthroat

Fish/100feet

* Number of reaches sampled

Figure 45. Longitudinal differences in the relative abundance of large salmonids for the main channel Willamette River and McKenzie River during March and September (Andrus 2000, Andrus et al. 2000).

Juvenile Chinook salmon were scarce in the main channel of the Willamette River and McKenzie River, with captures at only 2 sites in September, 2000, and 8 sites in March, 2000 (Figure 46). In March, values were highest at sites near the wastewater treatment plant outfall at the Beltline Road Bridge.
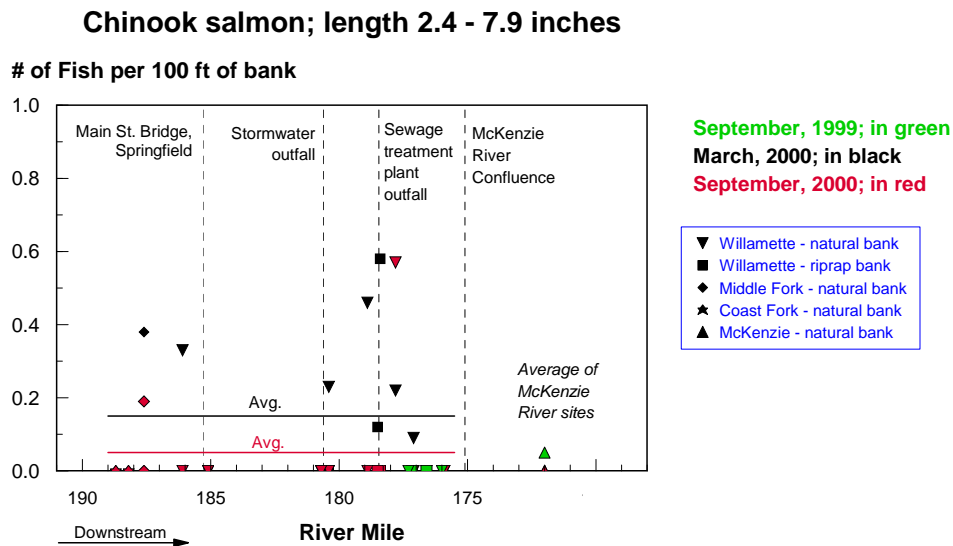
Chinook salmon; length 2.4 - 7.9 inches

Figure 46. Longitudinal differences in the relative abundance of small Chinook salmon for the main channel Willamette River and McKenzie River during March and September (Andrus 2000, Andrus et al. 2000).

Few juvenile Chinook salmon caught in the McKenzie River had a clipped adipose fin, while 35% of Willamette River Chinook had a clipped fin in March (Table 23). This means that at least one-third of Willamette River juvenile Chinook are of hatchery origin, but the real proportion, while unknown, is probably much higher. The hatchery Chinook juveniles in the McKenzie River seem to be a much smaller proportion of all Chinook juveniles (Table 23), but the sampling periods were not coincident with the months that hatchery fish are released. Upon release, juvenile Chinook salmon raised in hatcheries quickly move downstream to the Columbia River (Snelling et al. 1993).

Table 23. Percentage of juvenile Chinook salmon with a clipped adipose fin during March and September sampling for the Willamette River and McKenzie River (Andrus 2000, Andrus et al. 2000).

	Willamette River	McKenzie River
March	35%	3%
September	18%	0%

Observations and informal sampling of juvenile Chinook salmon has taken place at other locations in the study area. Seining in the lower McKenzie River by the Oregon Department of Fish and Wildlife Research office and the Springfield office indicate that young Chinook juveniles can be seasonally found within pockets along the edges of the McKenzie River where

conditions are conducive to seining. Seining is successful only in areas with a finer substrate, low velocity water, a water depth of less than about 6 feet, and where the river bottom is free of wood and other obstacles that would snag a net. Consequently, seining can yield little information about fish in other habitat types. The McKenzie River, like all study area waters, is too turbid to observe fish by snorkeling. Results from seining in early spring through mid-summer suggest that young-of-the year Chinook move through the lower McKenzie River in spring with few Chinook born the previous year still present (Kirk Schroeder, ODFW Research, personal communication).

Scrapers

Small scrapers (largescale sucker, mountain sucker, and chiselmouth) were relatively uncommon throughout the main channel of the Willamette River and McKenzie River, except for certain sites between the Springfield Bridge and the McKenzie River confluence (Figure 47). In contrast, large scrapers were common with the highest densities near the wastewater treatment plant in September. Their numbers decreased with increasing distance downstream from the outfall. Large scrapers were relatively low upstream of the outfall. The wastewater treatment plant releases nutrients that probably fuel an abundant periphyton community that attracts the scrapers. This enhanced periphyton community is probably missing in March when sunlight is scarce and the water is deeper and more turbid.
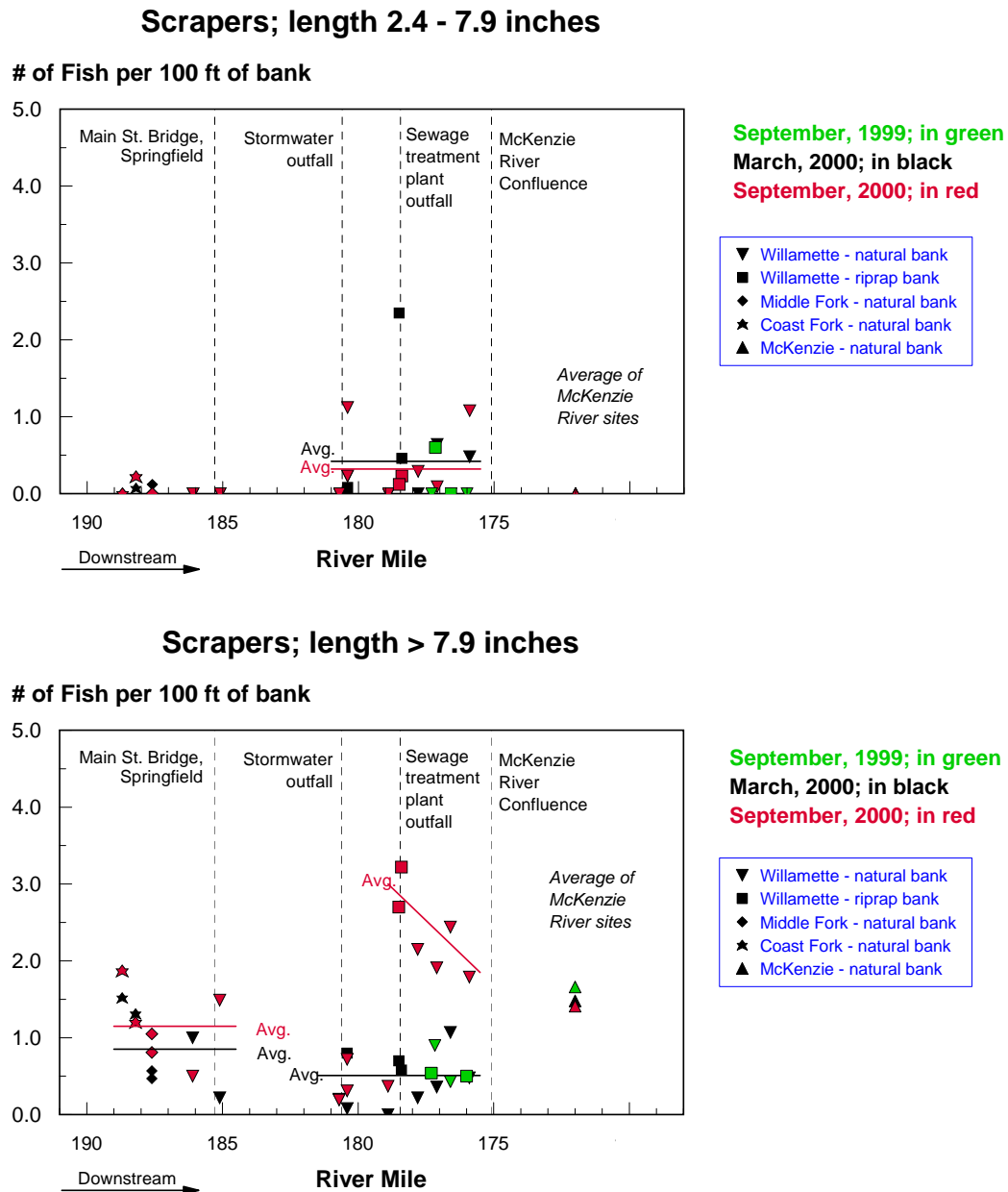
Scrapers; length 2.4 - 7.9 inches

Scrapers; length > 7.9 inches

Figure 47. Longitudinal differences in the relative abundance of scrapers for the main channel Willamette River and McKenzie River during March and September (Andrus 2000, Andrus et al. 2000).

Much has been made of deformities of fish occupying the Willamette River from the Wilsonville pool and downstream to the Columbia River. Here, skeletal deformity rates among native juvenile minnows are high and outer anomalies among other fish, especially introduced species, are reported to be high. Outer anomalies include lesions, parasites and infection of fins and skin, blind eyes, and injury. The reasons for the deformities are still being explored, but may include a combination of high levels of industrial pollutants and naturally-occurring warm water.

Outer anomalies in the upper Willamette River basin are rare for most fish. In an evaluation of fish in the Willamette River and lower McKenzie River, less than 1% of fish 2.4 to 7.9 inches had outer anomalies, while fish over 12 inches (excluding largescale sucker) had an outer anomaly rate of 5% (Andrus et al. 2000). Salmonids were relatively free of anomalies, with cutthroat trout having none.

In contrast, outer anomalies among largescale sucker greater than 12 inches long were common in March, especially in sections of the river least expected to have water quality problems (Figure 48). Water temperature is not expected to be a factor in disease susceptibility during March since the temperatures of all rivers in the study area are low. September outer anomaly rates were somewhat higher than those in March.

Outer anomaly rates decreased from 26% in the section upstream of the Springfield Bridge to 13% downstream of the wastewater treatment plant. Rates were highest in the McKenzie River at 32%. The abundance of food available to largescale suckers in early spring may be negatively correlated to anomaly rates. Extra food in the portion of the Willamette River flowing through Eugene may be a result of extra nutrients provided by stormwater and treated wastewater effluent. A well-fed fish may be more capable than an ill-fed fish to ward off disease.
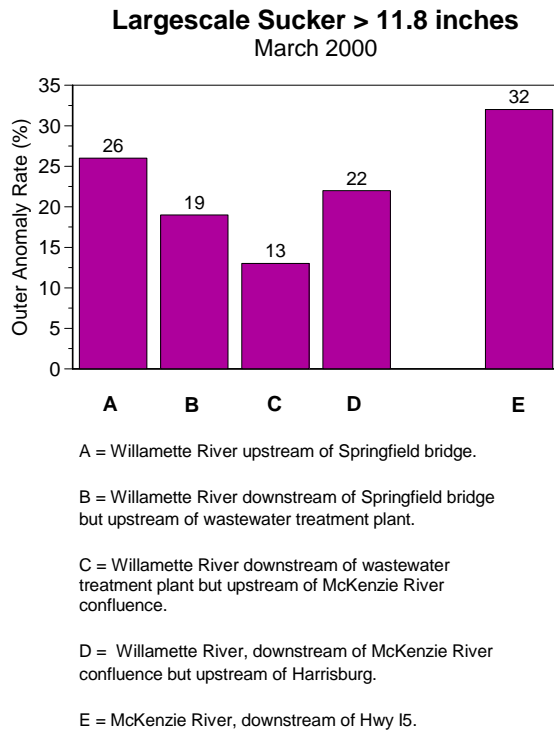
Largescale Sucker > 11.8 inches
March 2000

A = Willamette River upstream of Springfield bridge.

B = Willamette River downstream of Springfield bridge but upstream of wastewater treatment plant.

C = Willamette River downstream of wastewater treatment plant but upstream of McKenzie River confluence.

D = Willamette River, downstream of McKenzie River confluence but upstream of Harrisburg.

E = McKenzie River, downstream of Hwy I5.

Figure 48. Outer anomaly rates among largescale sucker greater than 12 inches long in March for sections of the Willamette River and McKenzie River.

Fish community variation among water and bank types

Data compiled from the Willamette / McKenzie confluence study (Andrus et al. 2000), the City of Eugene study (Andrus 2000), and a study downstream of the McKenzie River confluence (Andrus, unpublished data) provide the opportunity to compare fish assemblages among water types and for different bank types along the main channel. Included are sites for gravel pits, alcoves, and the main channel. Main channel sites had either natural banks, riprapped banks, or riprapped banks with rock barbs. The gravel pit ponds were connected to the river only during high flows. Table 24 provides a summary of the number of sites sampled for each type for both March and September sampling.

The relative abundance of small native fish in March was considerably higher at sites with rock barbs along the main channel than at any other type of site (Figure 49). Yet, by September, most of these small fish were gone and these sites became the domain of large trout. The diet of large trout can include small fish. Native fish within <u>alcoves</u> for the Willamette River generally increased with increasing distance downstream of the Springfield Bridge, while the relative abundance of native fish in the <u>main channel</u> decreased. The lower McKenzie River had more native fish at main channel sites than at alcove sites during March. The reverse was true for Willamette River sites; alcoves had more fish than main channel sites. McKenzie River alcoves were deeper than Willamette River alcoves and lacked aquatic plants and other cover features

and so they may have been less desired by small fish. Gravel pits had the lowest relative abundance of native fish in March.

Table 24. Number of sampling sites by season, water type, and section for boat electrofishing in March, 2000, and September, 1999.

Sampling	Water Type	Number of Sites Sampled					
		McKenzie R.	Willamette R. upstream of confluence		Willamette R. downstream of confluence		Total
	Section	**1**	**2**	**3**	**4**	**5**	
March 2000	Alcove	4	-	3	6	7	20
	Main channel						
	Natural bank	4	5	10	4	7	30
	Riprap bank	1	-	5	-	1	7
	Riprap bank w/ barbs	2	-	-	-	-	2
	Gravel pit pond	-	-	2	-	-	2
	Total	11	5	20	10	15	61
Sept. 1999	Alcove	4	-	1	3	-	8
	Main channel						
	Natural bank	5	-	3	2	-	10
	Riprap bank	2	-	4	-	-	6
	Riprap bank w/ barbs	2	-	-	-	-	2
	Gravel pit pond	-	-	2	-	-	2
	Total	13	-	10	5	-	28

Reaches: 1 = McKenzie River
2 = Upstream of Springfield Bridge
3 = Springfield Bridge to McKenzie Confluence
4 = McKenzie Confluence to Harrisburg
5 = Harrisburg to Corvallis

In September, alcoves were dominated by small native fish while main channel reaches were dominated by large fish. Native fish in gravel pit ponds decreased to very low numbers by September.

Main channel sites with riprap had about the same number of native fish as main channel sites with natural banks, although some riprap sites (those with the fastest water) had very few fish.

Native Fish
March, 2000 sampling

Native Fish
September, 1999 sampling

1 = McKenzie River
2 = Upstream of Springfield Bridge
3 = Springfield Bridge to McKenzie Confluence
4 = McKenzie Confluence to Harrisburg
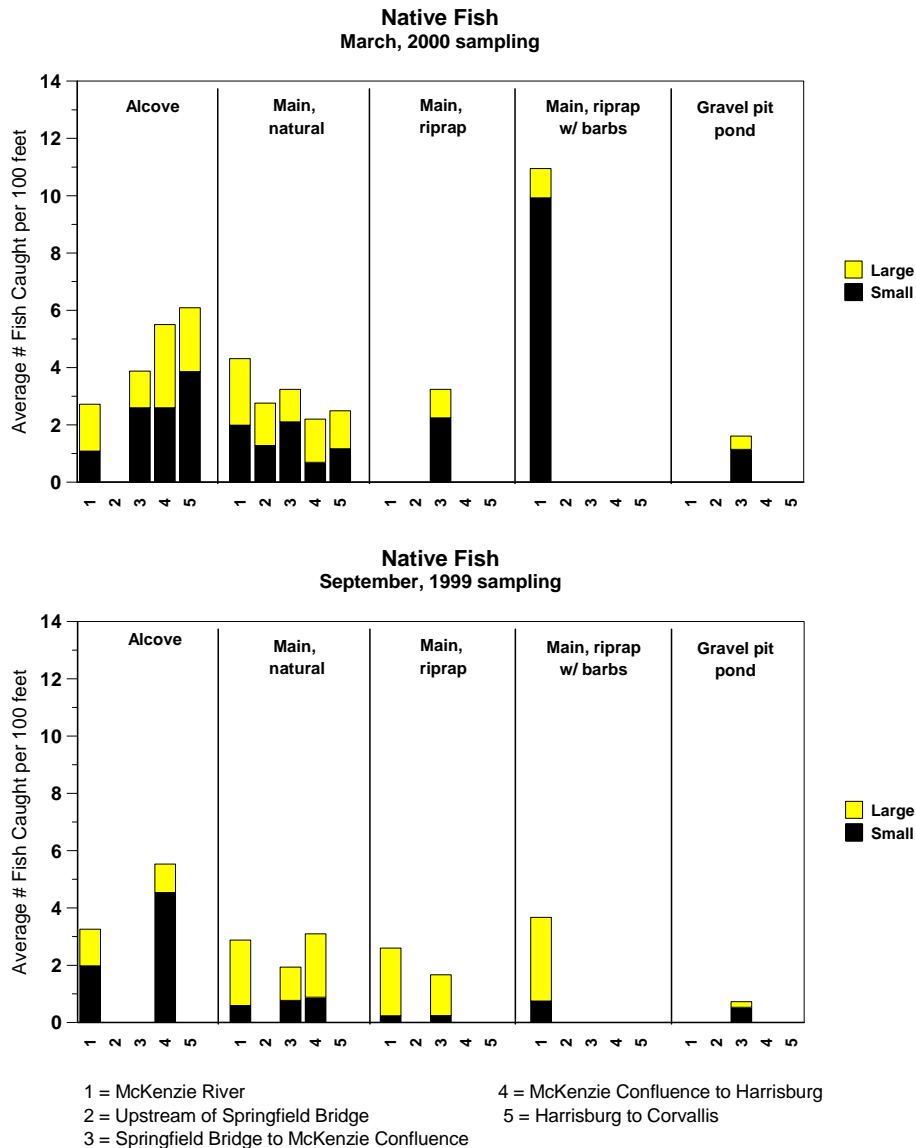5 = Harrisburg to Corvallis

Figure 49. Summary of the relative abundance of all native fish by water type and bank type for various sections of the Willamette River and McKenzie River for September, 1999 and March, 2000. "Main" means the main channel of the river. Sections with no values for a specific water type indicates that no sampling took place.

The relative abundance of salmonids in March was greatest in the McKenzie River at main channel sites with natural banks or with rock barbs (Figure 50). Sites with natural banks were dominated by mountain whitefish while rock barb sites were dominated by juvenile Chinook salmon and trout. By September, the juvenile Chinook salmon and most other small fish were gone from the rock barb sites and very large rainbow trout occupied these slackwater areas instead. Presumably, the rainbow trout benefit from the proximity of low velocity water for resting and high velocity water for feeding.

Alcove sites had fewer salmonids than did main channel sites in March, except for main channel sites with riprap. Gravel pit ponds had only a few salmonids in March which then died by September. A single Chinook salmon was caught at one of the gravel pit ponds in March, suggesting they are not trapped within inundated gravel pits in large numbers. Both gravel pit ponds were much warmer than the main channel of the Willamette River during the summer.

Main channel sites during September had a high abundance of large salmonids in the McKenzie River and Willamette River downstream of the McKenzie River confluence, but few in the Willamette River immediately upstream of the McKenzie River confluence.

Salmonids
March, 2000 sampling

Salmonids
September, 1999 sampling

1 = McKenzie River   4 = McKenzie Confluence to Harrisburg
2 = Upstream of Springfield Bridge   5 = Harrisburg to Corvallis
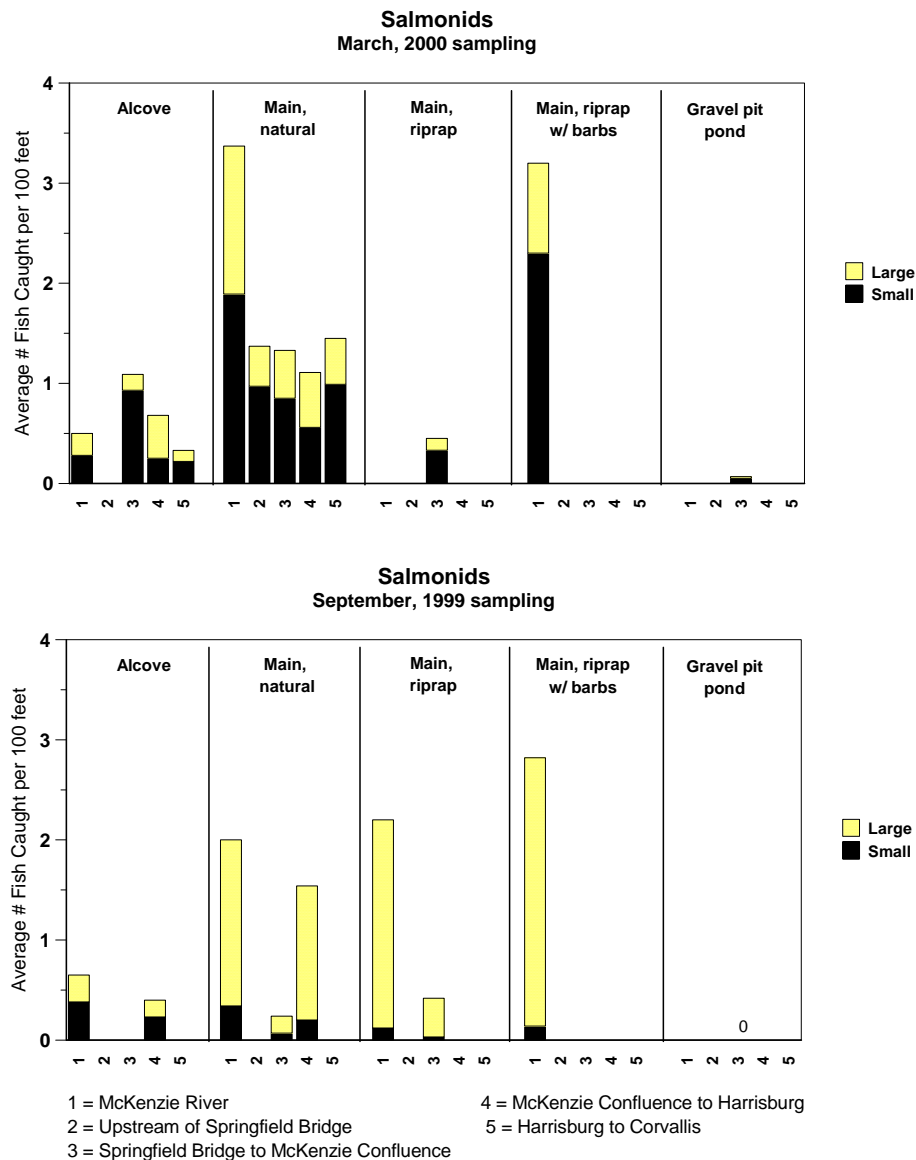3 = Springfield Bridge to McKenzie Confluence

Figure 50. Summary of the relative abundance of salmonids by water type and bank type for various sections of the Willamette River and McKenzie River for September, 1999 and March, 2000. "Main" refers to the main channel of the river. Sections with no values for a specific water type indicates that no sampling took place.

Introduced fish were absent from all main channel sites and present in only low densities within alcoves (Figure 51). Most introduced fish were small, consisting largely of bluegill and largemouth bass. In contrast, the relative abundance of small introduced fish in gravel pit ponds was high for both March and September. Few intermediate-sized largemouth bass were caught; most were either less than 4 inches long or greater than 12 inches long. Since the gravel pits have no surface connection with main channel during the summer, native predatory fish, such as northern pikeminnow, cannot feed on the small exotic fish. Alcoves, even those with warm water during the summer, are readily entered by northern pikeminnow (usually at night) and feed on introduced fish, thereby keeping them at low densities.
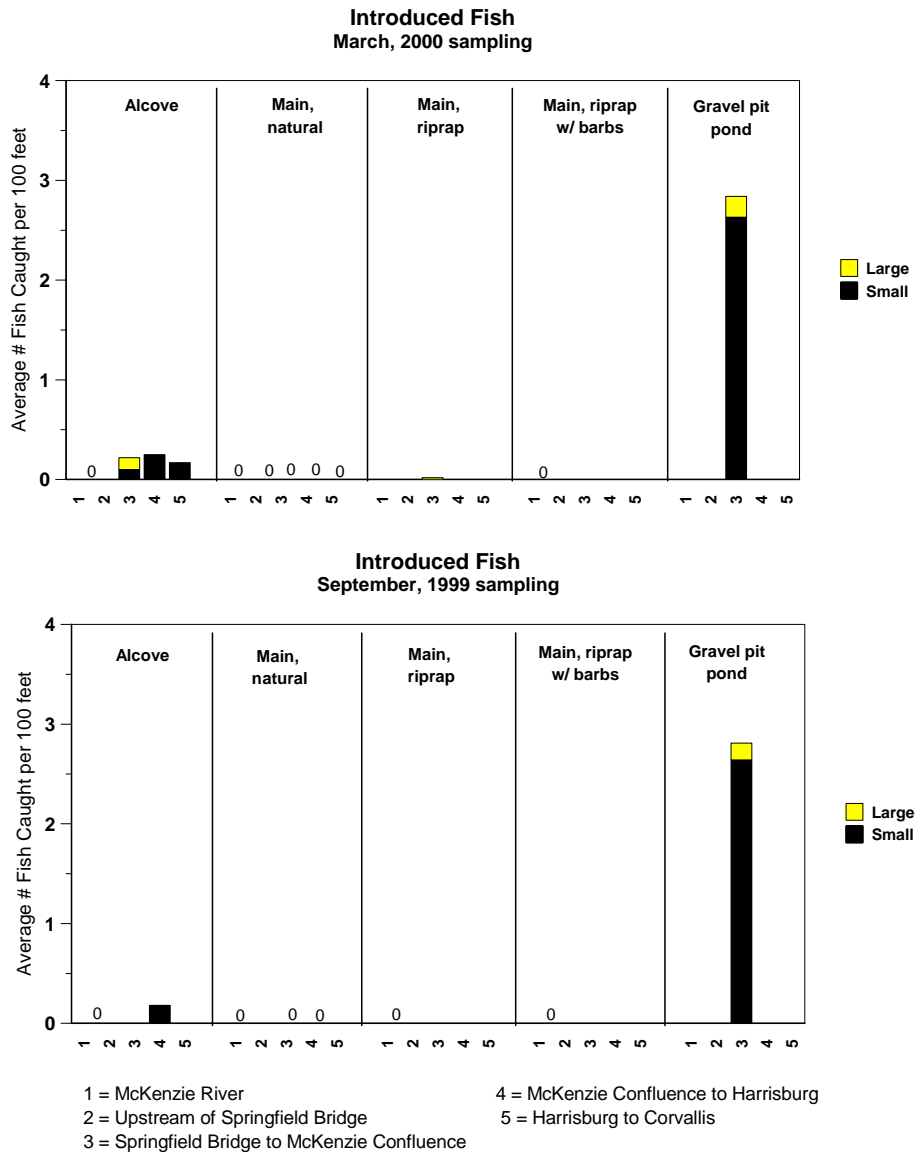
Introduced Fish
March, 2000 sampling

Introduced Fish
September, 1999 sampling

1 = McKenzie River
2 = Upstream of Springfield Bridge
3 = Springfield Bridge to McKenzie Confluence

4 = McKenzie Confluence to Harrisburg
5 = Harrisburg to Corvallis

Figure 51. **Summary of the relative abundance of introduced fish by water type and bank type for various sections of the Willamette River and McKenzie River for September, 1999 and March, 2000.** "Main" refers to the main channel of the river. Sections with no values for a specific water type indicates that no sampling took place.

4.1.3 Barriers to fish movement

Only two small streams in the study area have been surveyed for culverts and other barriers that would block upstream fish movement. A survey by the Oregon Department of Fish and Wildlife and Salmon-Trout Enhancement Program (STEP) volunteers in April, 2001 indicated that none of the 10 city culverts in Spring Creek had characteristics associated with the blockage of fish.

Similarly, 12 out of 13 culverts surveyed in Flat Creek seemed to pass fish. They found that a culvert at Irving Road had been dammed and screened to create a pond about ¼ mile in length as part of a housing development. This dam is a barrier to fish. When we checked this site in April, 2002, the dam was still present.

A number of piped sections of stream throughout urban portions of the study area probably keep fish from entering upstream portions of small basins. For example, Russell Creek in southeast Eugene is piped underground at the community college, thereby isolating the upstream portion of the watershed. Similarly, many tributaries of upper Amazon Creek are also piped underground at their lower ends. An unnamed tributary to the Middle Fork Willamette River (flows into reach 26 from the north) traverses through wooded property owned by a wood products mill and appears to be blocked by a perched culvert that flows underneath Jasper Road.

Fern Ridge Dam and several downstream irrigation diversion dams prevent fish from moving upstream from the Willamette River and spawning in the upper Long Tom River watershed. Removing these barriers to allow upstream movement of cutthroat trout and other fishes has been designated as lower priority for the Corps of Engineers and the irrigation district. Use of the lower portion of the Long Tom system by juvenile salmon originating from the McKenzie River and Middle Fork Willamette River for rearing and refugia during non-summer months is currently thought to occur (Jeff Ziller, ODFW, personal communication).

Determining whether or not fish have upstream access throughout a stream is time-consuming and can be done only by walking the length of stream (usually during higher water in early spring). This is difficult in an urban setting due to the many landowners and dogs that need to be appeased.

4.1.4 Potential interactions between hatchery and native trout

Rainbow trout raised at the Leaburg hatchery on the McKenzie River are transferred to MECT study area rivers and the Alton Baker Canal / Patterson Slough from February to July. These trout are a different variety than the native "redside" rainbow trout. Their pallid color, slight build, clipped adipose fin, and tendency to school make their appearance and behavior different than native rainbow trout. The hatchery rainbow trout are of a stock that does not normally breed or even survive the winter in the MECT area. During sampling of the rivers in the study area in March and September, only one hatchery rainbow trout was caught that had survived the winter, and it was heavily diseased (Andrus 2000).

About 62,000 hatchery rainbow trout greater than 8 inches long were placed in waters within or near the study area during 2002 (Table 25). Of those, over 18,000 were placed in the Alton Baker Canoe Canal. The bulk of the hatchery rainbow trout were put into the McKenzie River upstream of Hayden Bridge. Hatchery rainbow trout tend to school when released into a river. This, along with their aggressive behavior when feeding, will often result in local displacement of wild fish. Fortunately, they do not seem to wander far from where they are placed. The presence of these non-reproducing and easily-caught hatchery fish takes some pressure off the native trout and provides fishermen meat for the frying pan. Nevertheless, there is probably

some incidental catch of larger juvenile Chinook salmon by allowing bait fishing for hatchery trout in places such as the Alton Baker Canoe Canal. Although not confirmed by sampling, Alton Baker Canoe Canal has an unscreened diversion from the Willamette River. Juvenile Chinook are likely shuttled into the Alton Baker Canoe Canal in a manner that is similar to the juvenile Chinook salmon that are diverted from the McKenzie River into Cedar Creek in large numbers.

Interactions between juvenile Chinook salmon released from hatcheries and naturally-reared salmon are probably minor since hatchery fish commonly migrate downstream within a few weeks after they are released (Snelling et al. 1993).

Table 25. Number of hatchery rainbow trout (8 inches and longer) introduced into waters within and near the MECT study area during 2002. Most placed trout are 8 to 10 inches long, with about 4% averaging 12 inches.

Month	Alton Baker Canoe Canal	Lower McKenzie River	Lower Middle Fork Willamette River	Lower Coast Fork Willamette River
February	3,000			
March	3,900			
April	3,900	8,000	1,500	1,500
May	3,900	6,000	1,500	1,200
June	3,900	12,000	4,350	
July		6,000	1,150	
Total	18,600	32,000	8,500	2,700
Grand total = 61,800				

4.1.5 Fish harvest and regulations

The harvest of fish and the level of enforcement of fishing regulations can greatly influence the salmonid population of a river. Within the study area, fishing regulations and their enforcement vary widely (Table 26). Trout fishing in the lower McKenzie River is catch and release for wild trout and only artificial flies and lures are allowed. The other rivers have a 5 fish per day limit and fishing with bait is allowed from April to October. For all waters, steelhead and spring Chinook without a clipped adipose fin must be released.

Table 26. Fishing regulations for water bodies within the MECT study area for 2002.

Water body	Gear	Trout limit
Alton Baker canoe canal	Bait allowed	5/day (year-round)
McKenzie; mouth to Hayden Bridge (reaches 3-9)	Artificial flies and lures only	5/day (year-round)
McKenzie; upstream of Hayden Bridge (reaches 10-14)	Bait allowed (April to December)	5/day for hatchery rainbow trout (April to December); otherwise catch and release
Willamette upstream of McKenzie	Bait allowed	5/day (April to October); otherwise catch and release
Middle Fork Willamette	Bait allowed (April to October)	5/day (April to October); otherwise catch and release
Coast Fork Willamette	Bait allowed (April to October)	5/day (April to October); otherwise catch and release
Long Tom tributaries upstream of Fern Ridge Reservoir	Bait allowed (April to October)	5/day (April to October); otherwise catch and release
Other streams in study area	Artificial flies and lures only	Catch and release
Regulations applying to all waters: 　　No angling for bull trout. 　　Steelhead and Chinook salmon without a clipped adipose fin must be released. 　　No limits on warm water game fish; angling for warm water fish restricted to artificial flies and lures in streams and rivers.		

Funds for State Police and Department of Fish and Wildlife to enforce fishing regulations has decreased in recent years and so salmonid populations may suffer increased levels of poaching in the future. Self-policing by flyfishers and local guides has helped control illegal fishing to some extent.

4.1.6 Conclusions, recommendations, information gaps for fish

Fish populations in study area rivers are relatively healthy due to an abundance of cool water from the McKenzie River and Middle Fork Willamette River, the presence of good physical habitat in many reaches, and the lack of water pollution capable of affecting fish. Major factors that have caused three species to be federally listed as Threatened or Endangered are not directly tied to land use practices in the study area. The future of wild Chinook salmon is threatened mainly by the practice of mixing hatchery fish with the few remaining wild fish. The future of Oregon chub is threatened mostly by invasion of introduced fish into backwater areas and ponds. And, the future of bull trout, probably always an infrequent visitor to lower reaches of study area rivers, is tied to management of spawning and rearing habitat in the upper river basins, as well as, controlling poaching of adults.

Streams in the study area are more affected than rivers by land use practices. Stormwater inputs, an excavated channel, and lack of shading limits the Amazon Creek summer fish community to

tolerant species such as dace and redside shiners. The seasonal use of urban streams by trout and juvenile Chinook salmon is largely unknown, but they are probably present at least in the lower portions of streams during the winter. Blockages due to piping of streams probably limit their distribution in some basins such as Russell Creek and Amazon Creek. Artificial water features, such as the Alton Baker canoe canal and the Springfield Mill Race receive water (and fish) from the river and thereby provide habitat to native fish, at least during non-summer months.

The surges in peak discharge and poor quality water due to stormwater have the potential to severely degrade fish habitat in tributaries. Yet, except for certain streams draining into the Long Tom River basin (and also Spring Creek and the East Santa Clara waterway), serious stormwater problems have yet to materialize in the remainder of the study area, either because the stormwater is immediately diluted by river water (Cedar Creek for example) or development has not yet extended far into the basin (Pudding Creek, Russell Creek, and Willow Creek for example). Seasonal fish use occurs in some waterways specifically designed to convey stormwater, such as the Q Street Floodway, but the species and abundance of these fish is unknown.

Portions of the McKenzie River within the study area have exceptional habitat and water quality for Chinook salmon and other native fishes. Reaches 7 and 10 through 14 retain much of their pre-reservoir geometry that favor salmonids. Reach 13 currently lacks some of the channel complexity of neighboring reaches, but it could be restored to its pre-reservoir condition. Reach 24 on the Middle Fork Willamette River and reaches immediately downstream and upstream of the McKenzie River are also exceptional.

It is unclear why salmonid populations in the Willamette River upstream of the McKenzie River confluence and in the Middle Fork Willamette River are less abundant than in the McKenzie River. Water quality declines of the Willamette River as it flows through the urban area is probably not the cause since the relative abundance of salmonids is no greater upstream of the urban area. Differences between the McKenzie River and the upper Willamette River might be due to upstream reservoirs, river substrate, innate channel geometry, and fishing pressure. The upper Willamette River is more affected by peak flow decreases caused by dams, has fewer gravel deposits along its edges and bottom (a function of peak flow decreases and past in-channel gravel mining), and less restrictive fishing regulations.

Information is lacking on juvenile Chinook use of non-river waters within in the study area. Studies of tributaries elsewhere in the Willamette basin indicate that they search out the lower reaches of tributaries during the winter in search of refuge from fast water and to capitalize on terrestrial food sources. Surveys would need to be conducted during the winter or early spring, a time when sampling methods are least effective. Backpack electrofishing is difficult due to the large volume of water present, traps are time-consuming since they need to be visited daily to release fish, and seine nets often get snagged in small streams. Furthermore, the National Marine Fisheries Service has made it extremely difficult to obtain permits for sampling Chinook salmon. Permits applications often need to be submitted a year before the sampling occurs and the permits often come back with severe restrictions on what kind of sampling can occur.

Information is also lacking on the <u>fate</u> of juvenile Chinook salmon within certain waters throughout the year. For example, it is unknown whether or not the juvenile salmon that get shuttled into the Alton Baker Canoe Canal at its Willamette River inlet are surviving bass predation and angling pressure during spring and summer. If sampling indicates that juvenile salmon do not survive in the canal, then perhaps the inlet should be screened to keep them out. Other waters where summer survival of juvenile Chinook is in question include the Springfield Mill Race, Delta Ponds (Debrick Slough), and the near-river gravel pits that get inundated during the winter.

Recent discoveries of two small populations of Oregon chub within and near the study area suggest that other populations could also exist. Information is needed on where other populations are located prior to development or stormwater disposal in areas with preferred habitat. Priority areas to search are off-channel areas in reaches 10 to 14 of the McKenzie River, Oxley and Berkshire Sloughs, and off-channel areas in reaches 24 to 26 of the Middle Fork Willamette River. Paul Scheerer at the Corvallis office of Oregon Department of Fish and Wildlife is responsible for Oregon chub surveys and restoration efforts and is already searching for Oregon chub in some of these areas.

Efforts to protect and restore habitat for juvenile Chinook and other native fishes would logically focus on the lower McKenzie River and Willamette River reaches immediately upstream and downstream of the McKenzie River. It is there that the best remaining habitat and the greatest potential to restore their habitat exists. Nevertheless, there is also a legal responsibility, under the Endangered Species Act, to not engage in activities that result in the "take" of an endangered species, wherever they may occur. The take of an endangered species also includes the destruction of its habitat. Consequently, the use of juvenile Chinook salmon of lower portions of tributary streams and off-channel areas, even if it turns out that use is only seasonal and does not involve many fish, becomes an important issue in the local decision of stream management.

Finally, efforts to protect or improve habitat conditions for listed fish should also include a consideration of the entire fish community. There are other native fish species in the Willamette basin populations in decline (three-spine stickleback and sandroller are examples) and may be federally listed in the future. Attention to specific habitat needs of all native fish today can result in a more effective long-term response to protecting and improving fish habitat than focusing exclusively on species already listed.

Recommendations:

1. Two populations of Oregon chub have been recently located within and adjacent to the study area. More may still exist. Proposed development near sites that are favorable to Oregon chub survival (backwater areas with cold water which helps exclude bass) should be sampled prior to any activities in order to protect the last remaining populations of this endangered species.

2. Although there is a legal responsibility to protect habitat for the threatened spring Chinook salmon wherever it occurs, it's the rivers and not the streams which provide the best and most extensive habitat for juvenile rearing. Protection and restoration efforts should, therefore, focus on the rivers and especially the McKenzie River.

3. Restoration of Chinook salmon habitat in rivers is costly because it involves rearranging the channel to make preferred habitat features. Natural processes that once did this for free have been truncated by reservoirs and other human activities. Because of the high cost of creating these features, money spent on protecting existing high quality habitat is more cost-effective than restoring lost habitat.

4. Restoration of habitat for Chinook salmon and other salmonids should be directed at mimicking important habitat features that are now scarce. For example, several large logs with rootwads that are secured together at their bases with cable replicate log jams that once provided the nooks and crannies for fish to hide from predators and feed effectively in the current.

Information gaps:

1. Juvenile Chinook use of waterways other than the rivers and Cedar Creek is largely unknown for the study area. Current Chinook use of the Alton Baker Canoe Canal, Delta ponds, and the lower ends of Pudding Creek, Spring Creek, East Santa Clara Waterway, and Springfield Mill Race is suspected but cannot be confirmed. Fish sampling of these streams would best be done in March or April during low-flow conditions. Fish sampling should be accompanied by a survey of obstacles to upstream fish passage.

2. The fate of juvenile Chinook salmon that are shuttled into the Alton Baker Canoe Channel at an unscreened inlet is unknown. Information is needed on whether they try to stay in the channel into the summer season and survive bass predation and how many are inadvertently caught during the intensive fishing for hatchery rainbow trout.

4.2 Western Pond Turtle

The western pond turtle is the only native turtle in the upper Willamette River basin and it is declining rapidly mostly because of its failure to successfully reproduce (Holland 1994). Turtles seen within ponds, rivers, and streams are mostly old adults (15 to 30 years old) with few young turtles. Eggs and young turtles are often eaten by exotic animals such as opossum, dogs, bullfrog, and largemouth bass. Native species that consume eggs and young turtles include raccoons, foxes, and coyotes. A lack of top predators (mountain lion and wolf) has lead to a relatively high population of raccoons and coyotes in the Willamette River basin.

Bare areas are important to turtles since they will nest successfully only where vegetation is sparse and low-lying (Holte 1998). The eggs in their shallow nests require full sunlight and warming of the soil to develop. Yet, bare substrate along Willamette River basin waterways is now rare since aggressive exotic plants have been introduced and peak flows have been dampened by upstream reservoirs. Reed canarygrass, blackberry, and Scotch broom now aggressively occupy many water boundaries. Without floods capable of scouring vegetation and causing periodic shifts in the river boundaries, few bare areas are being created. Sites ideally suited for nesting have a cap of clay that hardens when dry and keeps the nest from caving in and are above the normal high water mark (eggs are deposited in June, young turtles stay in the nests over the winter, and emerge in the spring) (Holte 1998).

For lack of areas without dense vegetation, turtles will often use nearby plowed fields and active gravel roads, often with disastrous results (Bill Castillo, ODFW, Springfield, personal communication). Nesting is more successful where nests are near water since young turtles have a poor sense of direction once they emerge from the nest and are especially vulnerable to predation until they find water (Holte 1998). High islands within rivers offer some of the best conditions for minimizing predation and providing the young turtles immediate access to water. However, some terrestrial predators such as raccoons do swim.

Adult pond turtles often bask in the sun to regulate their temperature. Logs at the fringe or within the water are often chosen by the turtles for basking since they also offer some protection from terrestrial predators. Artificial ponds, such as gravel pits, often lack these logs.

Western pond turtles are relatively common in the MECT study area compared to other portions of the Willamette Valley. Sightings of pond turtles in the MECT area have been compiled and mapped by Eric Wold with the City of Eugene and include main rivers, gravel pit ponds, other excavated ponds, and streams. Pond turtles are particularly common in abandoned gravel pit ponds. Areas of highest pond turtle density in the MECT study area include: lower Amazon Creek (including the West Eugene wetlands), gravel pit and natural ponds near the McKenzie River confluence, within Delta Ponds (old gravel pits and sloughs), areas of slow moving water near the Middle Fork and Coast Fork Willamette River confluence (old gravel mining area), and along the south bank of the McKenzie River and its associated off-channel areas in the flood plain upstream of Springfield. Both juvenile and adult turtles have been observed in a small excavated pond near the Willamette River in the Santa Clara area.

The MECT study area has an unusual density of water features (rivers, streams, old gravel pits, natural ponds), thereby allowing local populations of turtles to interbreed and re-populate areas where turtles have died off. In addition, the bare substrate common to gravel extraction areas allows for some successful nesting. Furthermore, the urban setting of the MECT study area probably means there are fewer foxes and coyotes and, therefore, less predation on turtle nests. Gravel pit operations are usually closed to public access so this probably also reduces predation of nests by dogs and shooting of adult turtles by humans.

Activities to improve nesting success and to reduce predation on young turtles have been modest in the MECT area. Until this year, the Oregon Department of Fish and Wildlife in Springfield operated a "Head Start" program for western pond turtles where eggs were removed from nests, incubated indoors, and the young raised in tanks. Once the turtles were of a certain size, they were placed back into ponds and streams. This program was successful at supplementing younger age classes of turtles but has been discontinued due to budget cuts. Reproductive success at nest sites near Fern Ridge Reservoir was greatly improved by constructing wire cages around nests within 24 hours after egg deposition (Bill Castillo, ODFW, Springfield, personal communication). These efforts required a considerable amount of time since the turtle nesting season extends for several months and the nests are hard to find. At least one person is exploring the use of trained hunting dogs to sniff out turtle nests (Dave Vesley, Pacific Wildlife Research, Corvallis, personal communication).

4.2.1 Conclusions, recommendations, and information gaps for turtles

The study area is well-suited for western pond turtles. Waters capable of supporting turtles are numerous and interconnected. Pond turtles are still relatively numerous throughout the study area, though few young turtles are now seen. Turtles seem tolerant of a range of water quality conditions, ranging from the McKenzie River to lower Amazon Creek. Their most serious threat seems to be a lack of suitable nesting areas and predation upon their nests and young.

Successful nesting in the field will probably require that areas of bare substrate be maintained near high quality rearing habitat. This is challenging since exotic vegetation quickly invades bare areas and the riverside areas. Invading vegetation usually grows high and dense, thereby preventing the sun from warming the nest site and providing cover for predators. The Confluence Group (a combination of gravel extraction companies operating near the McKenzie River confluence, environmental groups, the McKenzie Watershed Council, and state and federal agencies) have initiated projects to improve pond turtle nesting and basking habitat along the Willamette River . Monitoring of turtle nesting success will be a part of this project. Data from sites where pond turtles are already reproducing successfully in the study area would be important for better understanding how to improve reproductive success. Abandoned gravel mining areas and natural sloughs provide some of the best opportunities for improving conditions for turtles.

Recommendations:

1. Efforts to restore wetlands, ponds, and their aquatic biota should include measures to provide

safe nesting areas for turtles. Safe sites include islands surrounded by deep water which helps repel predators and non-vegetated areas that allow the sun to warm the soil around nests.

2. Enlisting volunteers to help with the tracking and fencing of turtle nests can greatly improve turtle nesting success.

Information gaps:

1. Not much is known about the site conditions that are allowing turtles to nest successfully in the study area. A comparison of sites that have young turtles with those that have only old turtles may reveal which conditions are critical in this part of the Willamette Valley.

4.3 Macroinvertebrates

Benthic insects, worms, snails, mollusks, and other aquatic invertebrates, hereafter referred to as macroinvertebrates, represent a community of organisms that spend at least part of their life cycle within the substrate or water column of study area waterways. Macroinvertebrates are important participants in nutrient cycling processes that supply aquatic environments with organic material and other aquatic and terrestrial vertebrates with food. Macroinvertebrates occupy almost every available aquatic niche ranging from within and on almost all substrate types, to free floating in the water column, to skimming along the surface water-air interface. They exhibit a wide range of feeding and reproductive strategies.

The community of macroinvertebrates for a particular water body, when adequately understood, can provide information on the aquatic ecological system. Consequently, macroinvertebrate communities can be useful for assessing and monitoring changes to aquatic habitat, whether the change be related to natural or human disturbances. Via their varied life history patterns, sensitivity to microhabitat change, range of trophic roles, community resilience, and integration of relatively location-specific conditions into their community structure, macroinvertebrates offer a unique way to evaluate the habitat status of streams (Walsh 1996, Hawkins et. al. 1982, Kondratieff et. al. 1984, Pearson 1984, Towns 1981).

The examination of macroinvertebrate communities allows one to assess response to chemical (e.g., bacteria, heavy metals, and dissolved oxygen), physical (e.g., stream temperature, flow, and substrate) and habitat condition change (e.g., riparian/aquatic plant communities, and shade) (Kondratieff et. al. 1984). However, because macroinvertebrate community response varies widely according to the local setting, trying to determine a clear community response can be quite difficult. Both macroinvertebrate populations and the sampling of them are subject to high variability (McElravey et. al. 1989, Resh and Rosenberg 1989, Resh 1979, Cummins 1962, Needham and Usinger 1956). Sources of variability include:

- Life cycle and emergence patterns that can shift with changes in habitat (Newbold et. al. 1994, Towns 1985)
- Microhabitat preferences (including substrate, flow, and food availability) (Downes et. al. 1993, Reice 1980)

- Drift response (Richards and Minshall 1988, Hall et. al. 1980)
- Response to disturbance (Richards and Minshall 1992, Reice 1985, Pearson 1984)
- Recovery patterns after disturbance (Tikkanen 1994, Williams 1976, Waters 1964)

Sampling variability can be reduced by attention to sample collection techniques (Brussock and Brown 1991, Cummins 1962). For example, for monitoring stream conditions over time, macroinvertebrate samples should be collected:

- at the same sampling point
- from similar microhabitats (flow, substrate, light conditions) among sample sites
- at the same time of year each sample season
- using the same equipment and techniques each year (net mesh, sample area)

Macroinvertebrate information has been collected at a number of locations in study area streams and rivers (Table 27, Map 12). The collection objectives, methodologies, and consistencies differ in many respects among studies. Detailed descriptions of these projects, their methodologies, and their conclusions are available in Appendix B.

Table 27. **Macroinvertebrate sampling studies that have been conducted in the MECT study area.**

Water Body	Sampling Agent	Date	No. of stations	Quantifiable data	Site map reference*
Amazon Creek	ABA, Inc.	April 1999	3	Yes	1 – 3
	Anderson, T., W.R. Tinniswood and P. Jepson	December 1996, April 1997	4	No	4 – 7
	City of Eugene	April 2001	8	Yes	57-64
	Rachel Carson Natural Resource School	1999-2002	4	No	NA
Willow Creek	City of Eugene and Woodward-Clyde	1995	8	Yes	20 – 27
	Cary Kerst	1995-2002	NA	No	28, 30-32, 35
	Rachel Carson Natural Resource School	1999-2002	2	No	NA
A-3 Channel	DEQ	May 1996	3	No	38 – 40
Spring Creek	ABA	April 1999	1	Yes	41
West Eugene Wetlands	Steve Gordon and Cary Kerst		NA	No	NA
Cedar Creek	McKenzie Watershed Council	Fall 1998, Fall 1999	2	Yes	42
McKenzie River	McKenzie Watershed Council		2	Yes	44 – 45
Willamette River	City of Eugene	Fall/Spring 1994-2001	8-11	Yes	46 – 56

*Site map reference numbers correspond with sample site numbers on Map 12.

4.3.1 Evaluation of Sites and Methods

Overall, the basin-wide macroinvertebrate sampling effort, though uncoordinated, is fairly impressive. Some of the strengths of the available information are:

- Consistent use of a single lab to pick and identify samples and organize data
- Sampling over time at fairly similar sites
- Sampling at consistent seasonal times each year
- Involvement of local high schools and watershed councils in data collection efforts to help keep costs low

There are also weaknesses, however. Attention to sampling design planning and development was not as consistent among the study area macroinvertebrate efforts as it was to sample collection and interpretation. Though some projects demonstrate thorough planning and understanding of sampling design and macroinvertebrate sampling variability, others can improve. For example, sampling within Cedar Creek has not been collected consistently each year from the same locations. Data has been collected for three years at three separate, single-sample locations. This results in a database where year-to-year variability at a site cannot be distinguished well from site-to-site variability. If funding limits the ability to sample many sites every year for a period of time, sampling many sites in a single year and then doing this every few years yields better information than sampling single, different sites each year.

Though qualitative surveys, such as those performed by the Department of Environmental Quality on the A-3 Channel and C. Kerst and S. Gordon on Willow Creek and elsewhere, are less expensive than quantitative surveys, their results cannot be combined with quantitative surveys. Qualitative surveys may serve some specialized information need by a group, but they rarely add much to the general understanding of an area. Simple, non-systematic overviews of collected adults can be valuable as long as educated and interested volunteers consistently apply themselves to a particular region, much like bird watchers have done at times.

One of the greatest strengths of the MECT study area macroinvertebrate data is the consistent use of one or two third-party, professional laboratory firms that apply rigorous criteria to their sorting, identifying, and counting methods. All samples analyzed using ABA, Inc.'s standard sampling methodology were characterized by applying a multimetric bioassessment for Pacific Northwest *montane* streams. Except for the highest reaches on Amazon Creek, none of the sample sites in the study area correspond well to the montane index. ABA, Inc. is close to finishing development on a multimetric bioassessment for Pacific Northwest urban streams (personal communication, R. Wisseman). A more region-specific index may help tease out the complex interactions within macroinvertebrate communities between unique habitats and the broader environment.

Macroinvertebrates in Willamette Valley streams and rivers are best sampled in the spring or early fall. Fall sampling tends to be favored in larger systems because populations have had a chance to develop without significant flow disturbance. In addition, when sampling objectives are designed to attempt to determine response to particularly point source pollution, increased

spring flows may have a dilution effect, thereby reducing the likelihood of monitoring a macroinvertebrate response. Fall sampling should be considered in these and similar cases. However, because many smaller streams are dry in early fall, small system sampling may be more successful in the spring. In summer-dry systems, such as Willow Creek, spring sampling should be earlier. Because, emergence begins much earlier (e.g., in Willow Creek, 48% of 2,652 Ephemeroptera, Plecoptera, and Trichoptera collected in emergence traps emerged before April 1), early March is a more appropriate time. In perennial systems, spring sample timing should aim for April to remain consistent with previous sampling efforts in the MECT area. By this time, macroinvertebrate communities have recovered from disturbance caused by winter high flows, but have not yet experienced significant adult emergence (i.e., natural drop in population numbers).

For a single monitoring project, good sample sites are those with homogeneity, adequate flow, and no large changes in substrate during the season (e.g., from bare riffle to aquatic macrophyte growth). Because study area rivers are influenced by reservoir flow regulation, sampling sites on river channels will experience aberrant flow regimes when compared to natural flow conditions. Consistent sampling at a specific site may become difficult as riffles are unseasonally inundated. Sampled communities may exhibit abnormal characteristics as they respond to atypical changes in habitat conditions. Having backup sample sites for different flow conditions, recording flow levels at local USGS gauging stations at time of sampling, and sampling over time may help account for this source of variability.

4.3.3 Macroinvertebrate community overview

The following data synthesis was conducted to provide an overview of the aquatic macroinvertebrate community in the study area. In this multi-project macroinvertebrate data analysis, sampling sites that were fairly close to each other were grouped to discourage the tendency to search for effects based on a project's original objectives (which are not part of this data grouping objective) and to equalize longitudinal differences between sample points as much as possible (i.e., not to over-weight data differences among closely grouped sample sites compared to long unsampled reaches).

Because of the general overall emphasis of each study area project on generating the best data possible from the site samples (i.e., use of a professional laboratory for sample analysis), most of the data from different sample sites and projects could be grouped together to observe study area spatial and temporal variability. Despite this strength, however, grouping data from different studies for the purpose of evaluating cause and effects is strongly discouraged. Those sorts of conclusions can only be drawn using a focused, objectives-based sampling design.

In order to compare results of the various macroinvertebrate samples, we constructed the following indices from the raw data:

- Hilsenhoff Biotic Index (HBI). This index provides a picture of the macroinvertebrate communities' tolerance to pollution within their habitat. A low level indicates a generally intolerant community (more sensitive to environmental stressors) while a

higher value indicates a more tolerant community (less sensitive to environmental stressors).

- Brillouin H. This is a diversity index that measures the abundance (number) and richness (distribution of organisms among taxa) of a sample. Higher numbers reflect increasing diversity within the total sample population and, therefore, varied habitat and food sources able to support a more diverse community.

- EPT:Chironomidae. This ratio is a measure of the relative abundance of typically more sensitive Ephemeroptera (mayflies) , Plecoptera (stoneflies), and Trichoptera (caddis) genera with the typically less sensitive Chironomidae (true flies) populations. The closer this index is to 1, the more balanced the populations. Such a result, along with a coinciding substantial representation of the EPT genera, is one indication of positive biotic conditions within the sample area. Numbers greater than 1 indicate healthy habitat and decreasing numbers indicate proportionate increases in the tolerant Chironomidae family, or less favorable conditions.

- %Shredder. The shredder functional feeding group gathers its food from material that falls into the stream system from outside sources. They are typically associated with higher, headwater streams that are covered by a relatively complete riparian canopy that provides their food sources. Because of this headwater association, shredders are typically intolerant taxa. However, even in excellent conditions, one would not expect to find them in large amounts in a more open stream lower in the valley.

- %Collector-filterer. The collector-filterer functional feeding group is, as a whole, more tolerant of pollution and disturbance. Collector-filterers weave silk nets to filter suspended particles from the water. Increases in the percentage of collector-filterers could indicate increases in available food due to upstream disturbance or increased suspension of organics within the water column that favor this functional feeding group over others.

- *%Oligochaeta.* Oligochaetes, or aquatic worms, are a highly tolerant taxa that, though normally present in small numbers in most aquatic systems, become one of the few taxa to thrive under polluted conditions. Though not the only highly tolerant taxa, increases in percentages of Oligochaetes are fairly clear indicators of increasing pollution levels.

Study area setting

In general, little habitat data was collected with the aquatic insect samples. Some projects did record that samples had been collected in a riffle or run environment. However, other projects identified the sample site as simply "riffle/run" and others did not identify the site other than by geographical location. Therefore, determining habitat quality, similarities, or differences among the sample sites or grouping sample sites by habitat types in the figures below to further account for sample variability was not possible.

Observationally, however, it is clear that a wide range of macroinvertebrate habitat conditions are potentially present within the study area. Within the smaller non-river waterways, the south end of the study area contains forested/valley headwater systems, such as upper Amazon Creek and Willow Creek, that are undergoing development. Between these two headwater systems, food sources, gradient, substrate, and flow conditions vary dramatically from a macroinvertebrate microhabitat perspective. Proceeding northward, small stream systems are affected by urbanization including excavation, channel straightening, stormwater pipe outlets, removal of riparian vegetation, and bank and substrate hardening. These modifications have the potential to dramatically affect macroinvertebrate habitat by altering food and energy sources and channel hydrology and hydraulics. There is also natural variation; streambeds in the basalt geology are usually rich in gravel while streams in the Missoula flood deposit geology are lined mostly by fine material.

Heavily-impacted urban waterways that were sampled included lower Amazon Creek and Spring Creek. Cedar Creek flows along the north side of Springfield and is likely influenced by McKenzie River hyporheic flow, riparian vegetation, and channel movement. For these reasons, it exhibits unique attributes including mixing of small stream/large river and more rural/urban pollution influences.

In the river systems of the Middle Fork, Coast Fork, Willamette, and McKenzie Rivers, macroinvertebrate habitat conditions are highly variable. Microhabitats in terms of flow conditions and substrates can range from backwater depositional areas to rapid shallow flow over smooth substrates within one cross-sectional area of a river. Consistent attention to sample location type is critical to obtain comparative data. Samples that have been collected on the Willamette River since 1994 have all been collected from "classic" riffle environments (including the most downstream site, #46) with the exception of the two sample sites below Beltline. No riffles were present in this area to sample (Kerst, personal communication). However, these collection sites are critical to the testing of the project hypothesis and, therefore, are defensible. A balance of ideal sample location characteristics and project objectives is always necessary. Accurate and thorough recording of differences and basis for decisions made can account for these situations.

Longitudinal change

Longitudinal change in taxa and functional feeding groups as related to habitat change is a commonly accepted macroinvertebrate community structure theory (Statzner & Higler 1986, Vannote et. al. 1980, Towns 1979). The assumption is that as micro- and macro-habitats and dominant food sources change in a downstream direction, the macroinvertebrate populations will reflect this by changing as well. The shredder functional feeding group, for example, will be a larger percentage of the population in smaller streams with dense surrounding vegetation but a smaller percentage in larger systems with less terrestrial organic inputs and greater flows. The collector-filterer functional feeding group, on the other hand, will be less represented in smaller streams which are nutrient poor and more abundant in larger streams where more material is transported within the water column.

Indeed, this phenomenon is reflected in the pooled MECT macroinvertebrate data (Figure 50), showing a pattern of greater abundance of the shredder feeding group in the headwater systems and less representation in the larger rivers. The clearest example of this relationship is on the Willow Creek system. The Willow Creek data was collected in 1996 for the specific purpose of serving as baseline data prior to basin development (Woodward-Clyde, 1996). Though the stream is dry in the summer, data from Willow Creek offers probably the most "pristine" macroinvertebrate populations of all available data. Shredder populations on Amazon Creek are fairly low, despite heavy riparian vegetation. Sedimentation, altered hydrology from stormwater inputs, and increased hydraulic forces caused by channelization, three conditions that would discourage shredder populations and favor more collector-type functional feeding groups, already affect the Amazon Creek system by this point in the basin. Vegetation inputs also shift on Amazon Creek from predominantly leaf litter detritus to grass and blackberry leaves soon after Dillard Road. Anderson et. al. (1997) observed in their report on Amazon Creek a general lack of intolerant shredders such as stoneflies (which are commonly associated with leaf litter mats) and the dominance of more tolerant shredders such as chironomids in reaches that were dominated by overhanging exotic vegetation species (e.g., reed canary grass and blackberry) (for more discussion on this report, see Appendix B).
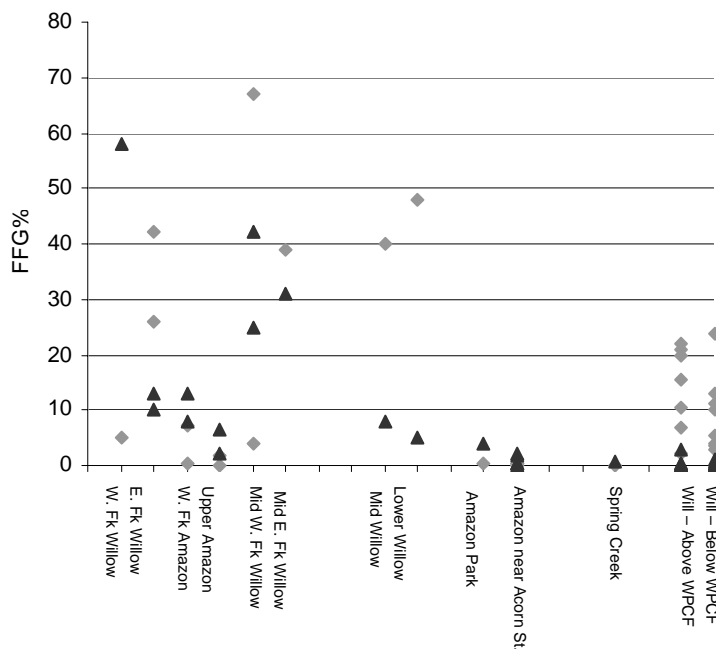

Figure 52. Spring % shredder (▲) and % collector-filterer (◇) functional feeding groups (FFG) from headwaters of Amazon (Willow Creek) to the Willamette River below the wastewater treatment plant. 1994-1999 data.

Collector-filterer populations do not exhibit as clear a response to longitudinal change. This could be expected because collector-filterers feed on a broader range of food types than shredders and, as a group, are not clearly tied to the presence or absence of a particular food source. In addition, many of the small streams in the study area are influenced by pollution and other abiotic factors which may already be loading the water column with nutrients. Kondratieff

et. al. (1984) observed that stations stressed by urbanization were dominated by collector-gatherers and filterers to the virtual exclusion of scrapers. Some of the stations high up in the study area may already be stressed enough to exhibit these shifts. In the case of some of the more urban-influenced study area waterways such as Amazon Park and Spring Creek, the longitudinal change model fails to hold as collector-filterers are eliminated from the sampled populations (Figure 52).

The clearest possible traditional example of a shift to collector-filterer feeding groups is not observable longitudinally. The Willamette River data points show that above and below the Eugene-Springfield Water Pollution Control Facility (WPCF), collector-filterers are consistently more abundant than the shredder populations over time (from 1994 to 1999). The collector-filterer populations sampled in the spring are the less abundant of the spring/fall collector-filterer cohorts. Figure 53 shows that fall populations of collector-filterers consistently make up a larger portion of the population on the Willamette River.
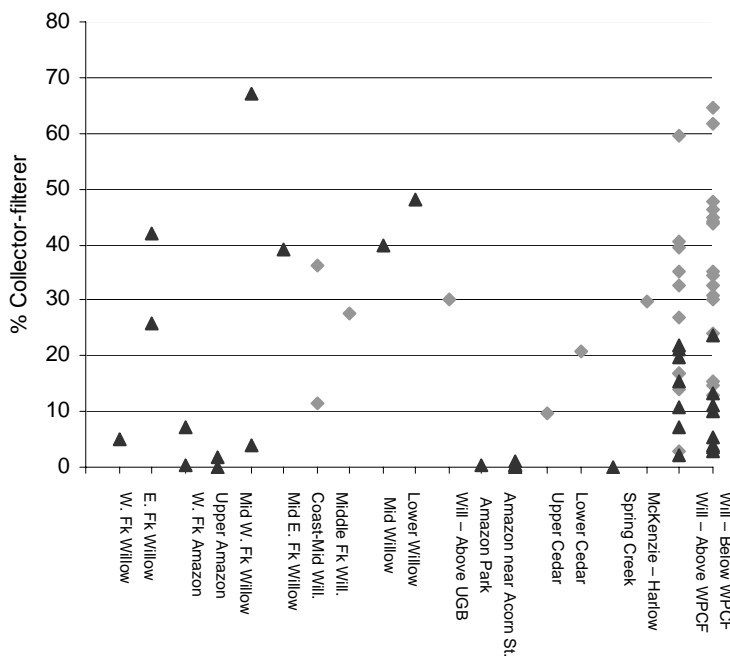

Figure 53. **Percent collector-filterer populations in the MECT study area from headwater to lower river reaches for spring (▲) and fall (◇).** 1994-1999 sample data.

In Figure 52 and 53, both shredders and collector-filterers exhibit depressed populations in the middle reaches of Amazon Creek and in Spring Creek. These reaches are heavily affected by urbanization including stormwater inputs, pollution sources, reduced riparian vegetation, and increased sedimentation. There is a notable difference in collector-filterer population percentages between the Lower Willow Creek site and the Amazon Creek Acorn Bridge site. Little less than a mile separates these two sampling sites. However, the Willow Creek functional feeding group community is almost 50% comprised of collector-filterers while the Amazon Creek site's community is 0.2% collector-filterer. Continued sampling over time, additional selection of sampling points related specifically to this hypothesis, and the same sampling

methodology would need to be applied to determine what factors were causing this difference in populations between the two nearby systems.

Seasonal change

Macroinvertebrate sampling efforts within the study area occurs in both the spring and fall. Both seasons are acceptable periods for sampling macroinvertebrates. Understanding the natural variability of a community is important in being able to sort out possible disturbance effects (McElravey et. al. 1989, Cummins 1962). Seasonal community responses are part of the natural variability that occurs outside the effects of anthropogenic disturbance. Whiting and Clifford (1983) observed that macroinvertebrate diversity was lower in urban streams in the spring because large numbers of tubificids [aquatic worms] were present. Though their large numbers were likely enhanced by organic enrichment, the surge in numbers could also be part of natural life history. To determine whether seasonal sampling differences might contribute to variability within the study area macroinvertebrate community information, Figure 54 displays the Brillouin H index from headwater to rivers. Willow Creek is not included because Brillouin H was not calculated for that project. However, because sampling in the fall is not an option for this system, its absence is not critical.
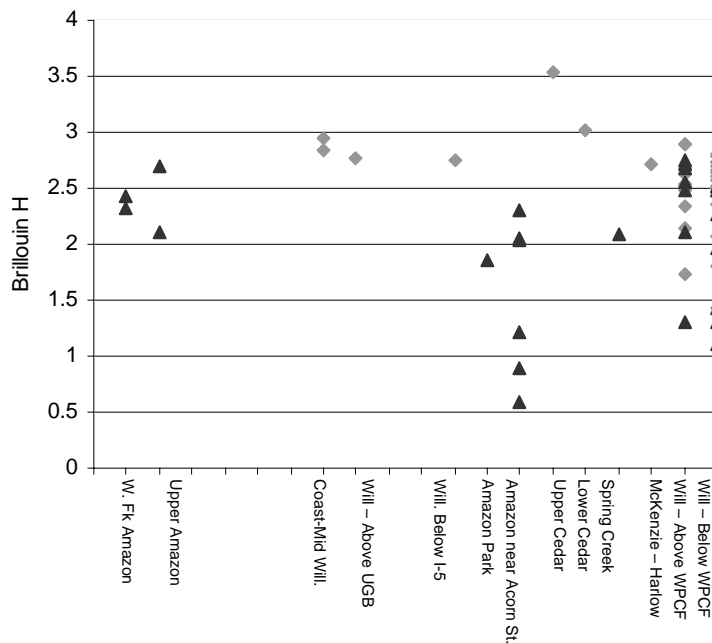

Figure 54. Brillouin H for spring (▲) and fall (◇) samples taken throughout the MECT study area from 1994-1999.

In general, there does not appear to be an observable difference in sample diversity between spring and fall. This is further supported by the overlap in the Willamette River samples. This data set was the only one currently available that had both spring and fall samples taken at the same sample sites. Either a spring or a fall sample, and in one year (1995) both spring and fall, have been taken since 1994. The low fall Brillouin H metrics for the mid-Amazon sites are a result of local poor habitat conditions rather than season of sampling. The highest point is well

within the range exhibited by other sites. The Long Tom Watershed Council and the City of Eugene sampled this site in fall 2001 and spring 2002. With current funding, they will continue sampling in both fall and spring through spring 2003. Data for the later sampling dates were unavailable at this time. The planned sampling regime will allow analysts to observe potential differences between fall and spring sampling within this degraded system.

Though unrelated to sampling season, of particular note in terms of diversity is the upper Cedar Creek site, located near Cedar Flats Road. Though outside the study area boundary, the site was included because of the importance of Cedar Creek in terms of its potential response to Springfield's influences, its proximity to the McKenzie, and the lack of sampling data on the creek as a whole. Cedar Creek is a unique stream system closely tied to the McKenzie River because a water diversion provides river water to that portion of the stream downstream of the highway. It is noteworthy in Figure 54, that a single year and point's sample produced the macroinvertebrate community with the highest recorded diversity near the study area. Exploring the variability around this diversity value through increased spatial (more points) and temporal (more years) sampling would provide more information on Cedar Creek's habitat potential and current quality.

Healthy and degraded systems

Each study, even those with only a single data point, within the study area has asked a specific question about a site's condition. Those questions can only be approached with project specific data. However, because many of the projects implemented in the basin collected, identified, and counted macroinvertebrate samples using similar methods, a gross overview of study area hotspots for healthy and poor macroinvertebrate communities can be generated. These spots should be viewed as only a coarse guide to areas where aquatic conditions may be fairly healthy or are clearly poorer than general basin macroinvertebrate community levels. They cannot be interpreted from a cause and effect perspective. The factors which create the observed conditions are unknown until monitored. To examine trends of general macroinvertebrate community condition, three indices were chosen: the Hilsenhoff Biotic Index (HBI), EPT:Chironomidae ratio, and %Oligochaetes.
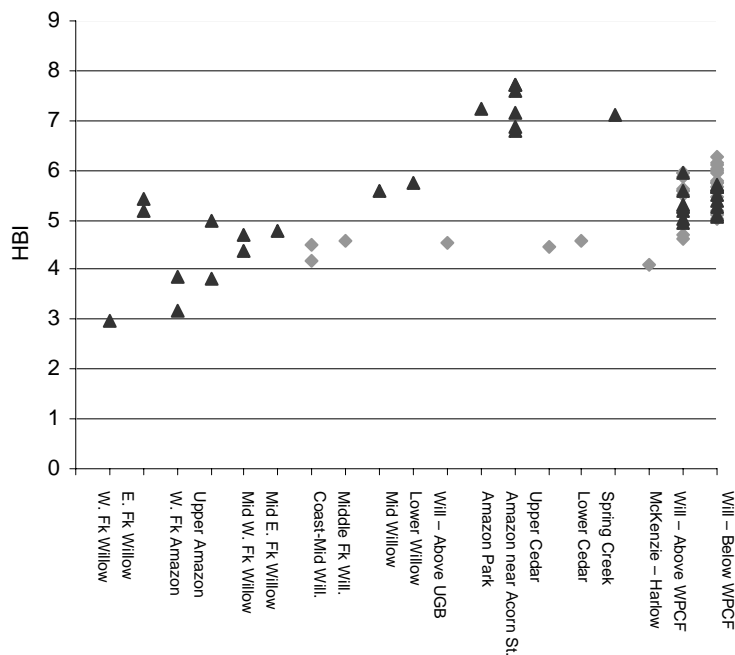
Figure 55. Change in HBI from high in the basin to lower river reaches for both spring (▲) and fall (◇) sampling seasons. 1994-1999 sample data.

In general, HBI remains fairly consistent through the MECT study area (Figure 55). Higher values of HBI indicate increasing response to organic pollutants within the system through changes in macroinvertebrate community structure. Some higher order reaches have slightly lower HBI values than average. Because there is little to no reference data for stream reaches in the upper Willamette Valley, it is uncertain whether the HBI values observed in Willow Creek are high, average, or low for these higher-order, smaller systems. The highest HBI values were observed for the middle reaches of Amazon Creek and Spring Creek. The McKenzie sample point shows fairly low HBI values for the sample area and the Cedar Creek sample sites are also fairly low.

Higher in the study area, in the smaller streams, the members of the Ephemeroptera, Plecoptera, and Trichoptera orders are far more abundant than the Chironomidae (Figure 56). Quickly, however, these ratios fall and through most of the urbanized areas, the ratio is fairly low. At some sample points, particularly in the middle reaches of Amazon Creek and at Spring Creek, no EPT cohorts were recorded and the ratio is zero. Ratios rise again inconsistently in the Willamette River. The fall sampled outlier for the Willamette River sampling points above the Eugene-Springfield Water Pollution Control Facility was caused by a sample that collected 525 EPT taxa and 13 Chironomidae. Over 200 Glossosoma caddis flies were collected alone (Kerst, personal communication, April 2002). Glossosoma are periphyton scrapers that do not tolerate sedimentation or large aquatic plants (Walsh 1996).
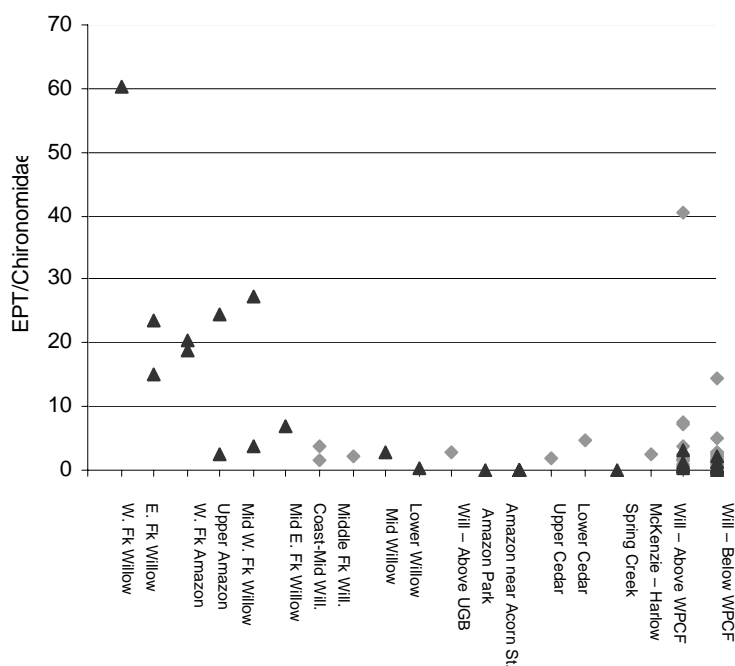
Figure 56. EPT:Chironomidae ratio for the spring (▲) and fall (◇) samples in the MECT Study area. 1994-1999 sample data.
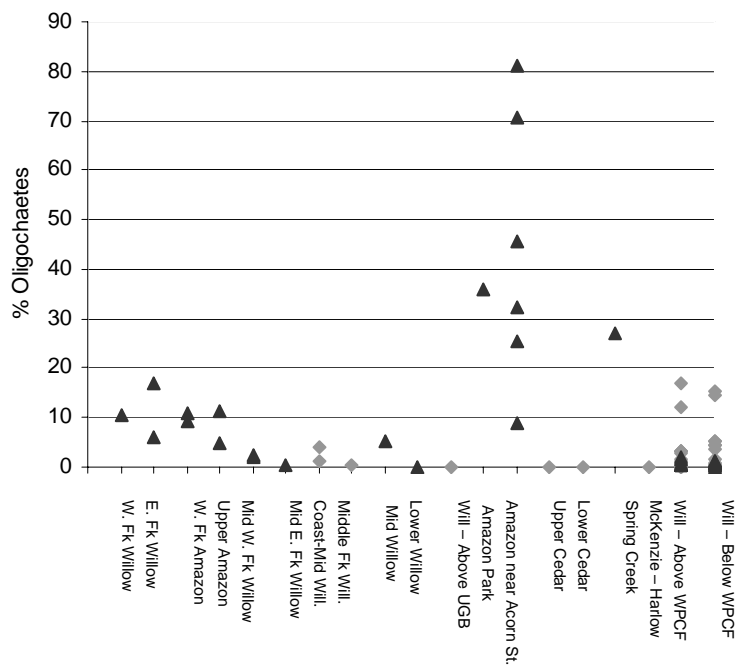

Figure 57. %Oligochaetes for spring (▲) and fall (◇) samples in the MECT study area. 1994-1999 sample data.

Oligochaetes or aquatic worms are highly tolerant aquatic invertebrates. They are common to most aquatic systems. However, they are one of the few tolerant taxa to thrive under severely degraded conditions. Their presence in the basin community is observed across all sampling

sites (Figure 57). If we exclude the middle reaches of Amazon Creek and Spring Creek, the proportion of sampled populations range from 0-17%. The middle reaches of Amazon Creek and Spring Creek, however, contain far greater percentages of Oligochaetes and reach as high as 82%.

In general, using the three indices of macroinvertebrate community health, the sample sites that exhibit relatively healthy community conditions are those at the upper headwaters of Willow and Amazon Creeks, Cedar Creek, and the McKenzie River. Sampled reaches on the Willamette River exhibit average to healthy macroinvertebrate populations for the study area. The middle reaches of Amazon Creek and Spring Creek are clearly more influenced by pollutants than the other sample sites. Because these measures are relative, however, the "healthy" site should be monitored if necessary to determine community response to urban influences. One cannot assume these sites will remain in their current relative condition. In particular, Cedar Creek, which currently exhibits consistently positive community metrics for the study area, should be monitored more extensively. The potential for pollution exists and the examined sample population was small in both time (one year) and space (two sites).

Willamette River focus

Data have been collected on the Willamette River since 1994 at the same sampling sites around the Eugene-Springfield Water Pollution Control Facility. In 1999, three new sampling sites were added to explore macroinvertebrate community condition above the Eugene-Springfield Urban Growth Boundary (UGB) and to compare these observed conditions to those monitored around the WPCF (for more detail on this project, see Appendix D). The WPCF-Willamette macroinvertebrate monitoring project provides the strongest data set in the study area because of its temporal and spatial consistency. Examined within the context of the overall study area as conducted above, the Willamette River sample sites exhibit a degree of variability probably found within many of the study area's populations monitored between years, seasons, and closely situated sample sites. However, because of sample site proximity to the WPCF and the recent sampling design expansion to address possible within-UGB/outside-UGB community differences, it is worthwhile to briefly examine the sites using the HBI pollution tolerance index and the Brillouin H diversity index.

To reduce between year and between season variability, only samples taken in 1999 and 2000 were used. Both years sampled in the fall. The two years were used because data for above the UGB and below I-5 were only available for 1999 and data for the Coast and Middle Forks were only available for 2000.

Figure 58 shows that HBI values on the Coast and Middle Forks, above the UGB, and below I-5 are relatively low, indicating a macroinvertebrate community with a greater sensitivity to pollution.
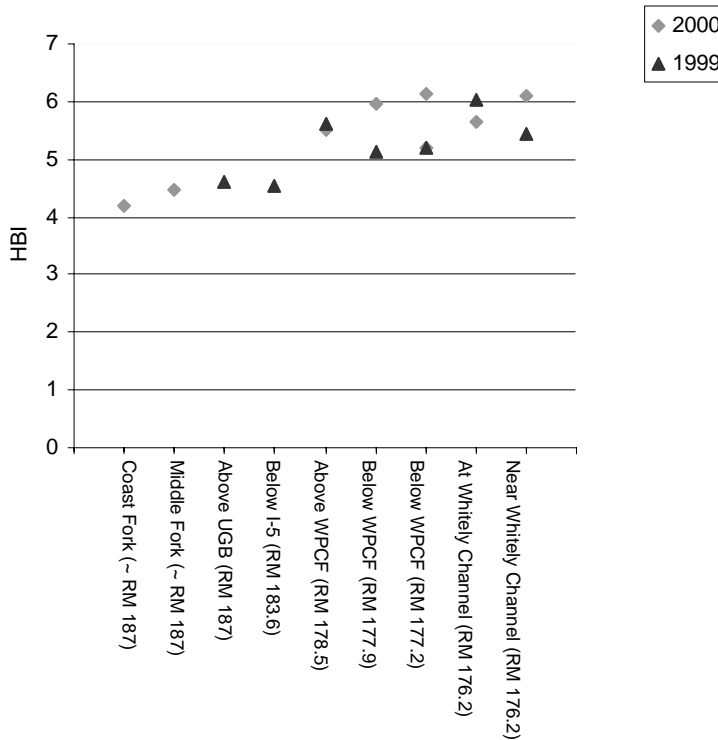
Figure 58. HBI for fall 1999 (▲) and fall 2000 (◇) samples on the Willamette Rivers within the MECT study area from the Coast and Middle Forks and above the urban growth boundary (UGB) to below the Eugene-Springfield Water Pollution Control Facility (WPCF).

Within the UGB around the WPCF, HBI values rise and, though there is variability between years, both years' samples indicate the presence of a macroinvertebrate community that tolerates more pollution than the insects above the UGB.

Community diversity, as described by the Brillouin H index, decreases slightly from above the UGB to below the UGB (Figure 59). The difference is not large though, especially when compared to the change between years at the same sample sites. Brillouin H values range from 2.36 to 2.95 among the Willamette River sample sites. In contrast, Brillouin H values for the entire study area ranged from 0.6 to 3.6. Variability between years at a few of the sample points was almost as great as the range between stations.
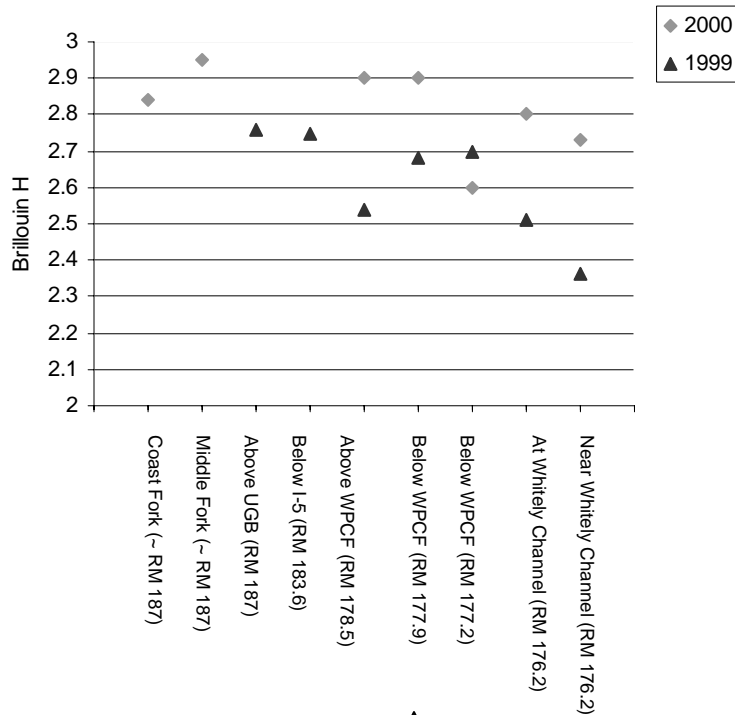
Figure 59. Brillouin H for fall 1999 (▲ and fall 2000 (◆) samples on the Willamette Rivers within the MECT study area from the Coast and Middle Forks and above the urban growth boundary (UGB) to below the Eugene-Springfield Water Pollution Control Facility (WPCF).

It should be noted as well that the EPT:Chironomidae ratio for these sample sites and years on the Willamette River showed no difference between macroinvertebrate communities above the UGB and those around the WPCF. The highest ratio value, which indicates a proportionately greater abundance of Ephemeroptera, Plecoptera, and Trichoptera populations compared to Chironomidae, was found in 1999 at the sample station near the entrance of Whitely Channel below the WPCF, the farthest downstream site.

4.3.4 Conclusions, recommendations, and information gaps on macroinvertebrates

In general, data collected throughout the study area indicate that the diversity and sensitivity to pollution of the study area's macroinvertebrate community appears relatively consistent. An exception is the macroinvertebrate community sampled in the middle reaches of Amazon Creek, which appear to be more tolerant of degraded water and less diverse. Macroinvertebrate communities in other study area waterways with conditions similar to these stretches of Amazon Creek may be expected to be as affected.

Excluding the urbanized reaches of Amazon Creek, the macroinvertebrate communities in study area non-river waterways do not differ greatly from those found in study area rivers. Though some smaller waterways, such as Cedar Creek and Willow Creek, contain more diverse and less pollution tolerant communities, in general, this consistency between systems is probably indicative of a moderately healthy river macroinvertebrate community and a possibly less-healthy non-river waterway macroinvertebrate community. However, reference data sets or

bioassessment indices are not currently available for Willamette Valley streams and rivers. Therefore, it is impossible to accurately define the health status of the macroinvertebrate community within the study area.

Recommendations:

1. For new projects yet to be implemented, use macroinvertebrate monitoring to assess physical habitat improvement. Suggestions include monitoring:
   - Planned restoration site for at least two seasons prior to installation, throughout installation, and then after installation
   - At the same time of the year
   - Within similar habitats (riffle/run, e.g.)
   - With the same intensity each time

2. Measure and record physical habitat conditions at sampling site since observed community structure changes can easily be misattributed without an understanding of background abiotic factors. This will help better account for background variability or conditions that affect the local macroinvertebrate community. Variables of interest would be:
   - Substrate size and composition and channel form
   - Shade and bank vegetation (understory and overstory)
   - Flow conditions

Many studies have demonstrated that substrate has a significant effect on observed macroinvertebrate communities (Reice 1980, Cummins 1962). Macroinvertebrate communities within riffles and pools can be quite different. Year-to-year variability can be more apparent in riffle habitats than in pool habitats. To attempt to account for these differences, record substrate and channel form at the sample site and sample consistently from the same substrate and within the same channel form (Brussock and Brown 1991, McElravey et. al. 1989). Hawkins et. al. (1982) observed that canopy type was a greater influence than substrate character on total macroinvertebrate abundance and functional feeding group representation. When attempting to determine effects of a disturbance other than canopy disturbance, select sample sites with similar canopy structure to reduce variability. McElravey et. al. (1989) also found that communities in years with peak discharges on a third order stream showed reductions in macroinvertebrate densities and increases in relative proportions of Chironomidae. Without knowledge of basic flow conditions, understanding this potential source of community response is much more difficult and ripe for error.

3. Continue to use ABA, Inc. or other similar services whenever possible. Encourage new project managers to do the same. Consistent analysis of samples allows for the comparison of data throughout the basin. In the data sets ABA, Inc. currently interprets for study area projects, they use a montane macroinvertebrate index that does not account for unique habitat conditions found in valley stream environments. ABA, Inc. will be releasing a new metric system sometime in 2002 that will improve upon the current set of metrics used to evaluate data. It will include allowance for more than one functional feeding group assignment, greater inclusion of response to local habitat changes (tolerance of temperature increases, substrate, etc.), and three separate indices for montane, mid-order, and riverine environments (R. Wisseman, personal

communication). In order to more accurately interpret the quality and health of a macroinvertebrate community, project managers should request that new valley floor waterway or river data sets being sent to ABA, Inc. be analyzed using this new bioassessment metric.

4. Except for monitoring to assess restoration efforts, discontinue general macroinvertebrate monitoring efforts on Amazon Creek. This stormwater flow channel continues to be affected by past management decisions and is constricted from any major change by the current urban setting. The aquatic macroinvertebrate communities along the stretches that flow through Eugene appear to be a long way from the point where community recovery would be observable. Negative cumulative effects from upstream polluted reaches will most likely be the primary inhibitors of monitoring any sort of significant change for the near future. Monitoring efforts and monies may be better applied elsewhere. One significant exception to this is the ongoing effort surrounding the Amazon Creek widening project near Acorn Park. The design, planning, and long-term focus of this project serve as an example of objective-based macroinvertebrate monitoring. If long-term monitoring is to continue on Amazon Creek, attempt to establish a reference site further up into the headwater area. Macroinvertebrate community dynamics are likely affected by the time the streams reach Martin Street. Natural springs abound up near Owl Road and could serve as spring and fall sampling sites.

5. Conduct further and intensified monitoring on Cedar Creek. Though this waterway currently exhibits fairly healthy community diversity, it stands to experience increasing effects from Springfield development. As a system, Cedar Creek also appears to be significantly connected to the McKenzie River. Along with other water quality parameters, there is the clear possibility that the two systems share macroinvertebrate communities through groundwater flow, intergravel communities, and aerial dispersal. Macroinvertebrate monitoring on Cedar Creek is recommended by the EWEB Stormwater and Urban Water Monitoring Plan to continue to support its objectives (EWEB 2001). A thorough review of the current macroinvertebrate monitoring plan design based on the objectives of various participating organizations is recommended to determine if questions will be answered in the plan's current format.

6. Attempt to coordinate with the USFS Blue River District and other larger basin stakeholders to help determine reservoir and flow regulation effects on macroinvertebrates. Expanding out to include samples collected within the larger "true" watersheds will greatly assist in understanding the current habitat condition of the study area and possible changes occurring within it.

Information needs:

1. Little is known about the macroinvertebrate communities in small Willamette Valley perennial streams that are undisturbed by development. Macroinvertebrate sampling of the undeveloped Pudding Creek would provide this information.